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USING SIMULATION TO ANALYZE THE UNITED STATES
ARMY EXPERT FIELD MEDICAL BADGE TEST

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APPROVED:

Supervisor:

J. Wesley Barnes
J. Wesley Barnes
Thomas A. Feo
Thomas A. Feo

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Dedication

To my wife, Lydia, and two daughters, Janin and Sandra.

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**USING SIMULATION TO ANALYZE THE UNITED STATES
ARMY EXPERT FIELD MEDICAL BADGE TEST**

by

JOHN CHARLES SEES JR., B.B.A

REPORT

**Presented to the Faculty of the Graduate School of
The University of Texas at Austin
in Partial Fulfillment
of the Requirements
for the Degree of**

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ABSTRACT

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JOHN CHARLES SEES JR., B.B.A

SUPERVISING PROFESSOR: J. WESLEY BARNES

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Chapter 1

INTRODUCTION

1.1 General

This report analyzes, through simulation, the United States Army's Expert Field Medical Badge Test. The Expert Field Medical Badge (EFMB) test is similar to a shop scheduling problem with stochastic processing times and daily time windows. Candidates for the badge demonstrate their skill in several tasks at predetermined locations and under specific conditions. In order to establish an efficient test site, the appropriate level of resources and a feasible schedule must be determined. To examine this problem, the EFMB test conducted by the Academy Brigade, Academy of Health Sciences, Fort Sam Houston was used.

This report is organized in the following way. The background of the EFMB test is presented and the current scheduling methodology of the Academy Brigade is examined. We then review the applicable literature related to the problem. Next a formal statement of the problem is given, followed by the research objectives of the report and how these objectives were met. In chapter two, the data collection plan is explained with the results of the data collection effort presented. Then the conceptual model and the simulation program are described. Following this, the experimental design for the study is given. The report then presents results and conclusions, and recommends possible

extensions.

1.2 Background

The EFMB Test is a Department of the Army program that recognizes highly skilled and proficient field medics. The Surgeon General has Army staff responsibility for the EFMB program and the Commandant of the Academy of Health Sciences, Fort Sam Houston, Texas, is the executive agent for the management of the program.

The EFMB test is a decentralized program conducted about every 12 months at over 50 locations around the world. Annually over 8,200 candidates compete for the EFMB. Of those eligible, about 22% meet the standards of the test.

The EFMB test is a series of physical and mental tasks. Candidates who successfully complete all phases of the EFMB test are awarded the Expert Field Medical Badge. The test requires satisfactory completion of prerequisite training before a performance test. Except for a written qualification test, all EFMB candidates complete these prerequisites in decentralized locations under the supervision of their unit commanders. Candidates are required to pass the Army physical fitness test, meet the qualification standards for their individual assigned weapon, and receive their commander's recommendation to compete for the EFMB. Once a candidate has successfully completed all prerequisites, he or

she is qualified to undergo the comprehensive written examination and then the performance test.

The comprehensive written examination covers emergency medical treatment, evacuation of the sick and wounded, field hygiene, NBC (nuclear, biological, and chemical) skills, survival training, general soldier combat knowledge, and land navigation skills. At the discretion of the administering commander, this test may be given before the performance test or as part of it.

The performance test is administered in a field environment. Each candidate is required to correctly perform the necessary actions for several established scenarios and tasks. This test consists of 38 tasks from the Expert Field Medical Badge Test Training Circular [1]. These tasks include survival skills, evacuation techniques, emergency medical treatment, communication procedures, cardiopulmonary resuscitation (CPR), day and night land navigation, and a litter (stretcher) obstacle course. A list of the prerequisites and the performance test tasks are given in Appendix A.

Each task has specifically defined criteria that must be achieved. Some tasks have performance times. For tasks without time standards, the commander administering the test may establish a maximum completion time. The duration of each candidate's performance on each task is stochastic and data on these durations is not historically available. Each candidate must complete all tasks within a 120 hour time frame.

The performance test is centrally located at an Army installation and serves a geographic region. This region includes local Army National Guard soldiers, individual ready reserve members, and other service members serving in comparable medical positions (i.e., Air Force, Navy, Marine, etc.). Medical specialists from the allied armies are also eligible. At each location, a committee (the EFMB board) is established to plan, coordinate, and execute the program.

The president of the EFMB board approves the organization of the performance test. In coordination with other committee members, he develops simulated combat scenarios around the required qualification tasks. Each test site may have a different ordering of tasks and different scenarios. These task groupings will be referred to as stations.

The EFMB board determines the required resources for each station. Most boards determine the quantity of resources based on estimates of the time required to complete the tasks and the number of tasks that are included in each station. Once the performance test begins, the EFMB board may add additional resources or change the testing schedule to solve bottleneck problems.

The number of candidates that are processed through the performance test depends on the number of medical personnel located in a test administration area and the number that successfully complete the prerequisites. For instance during 1991 at Fort Bragg, North Carolina, 325 candidates participated in the performance test while at Vicenza, Italy, 50 candidates participated.

The candidates are grouped together to maintain control, to plan transportation, and to coordinate meals. These groups are also used as the scheduling entity. In establishing the size of the groups, the EFMB board considers the distance between stations, the available transportation, and historical precedence.

1.3 Current Scheduling Methodology

The EFMB committee of the Academy Brigade relies on historical scheduling precedents and personal experience to organize and develop the performance test. The board first administers the comprehensive written examination. This is usually accomplished two weeks before the performance test. The results of this written test establish the number of candidates qualified to take the performance test.

Next, the board drafts an initial schedule separating the candidates into three approximately equal groups. An example initial draft schedule is illustrated in Figure 1.

G R O U P	1		2		DAY 3		4		5	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
A	*	NLN	CPR	DLN	ESW COM	ST	LOC	EMT	RM	
B	*	*	ESW COM	CPR	DLN	LOC NLN	EMT	ST	RM	
C	*	*	DLN	ESW COM NLN	CPR	EMT	ST	LOC	RM	

* Site setup

NLN-Night land navigation

ESW-Evacuation of sick & wounded

EMT-Emergency medical training

CPR-Cardiopulmonary resuscitation

DLN-Day land navigation

ST-Survival training

LOC-Litter obstacle course

RM-Road march

COM-Communications

Figure 1. Initial Draft Schedule

For planning purposes, each day in the initial draft schedule is divided into three periods. The morning time period (AM) is from 7:30 am to 11:30 am, the middle period is from 11:30 am to 1:00 pm, and the evening period (PM) is from 1:00 pm to 5:00 pm. Each group is scheduled for one station in the morning and one station in the evening. The middle period is tentatively scheduled for lunch and movement to the next station.

Some stations have time limitations, space limitations, or historical precedent limitations. For instance, the night land navigation (NLN) station is scheduled from about 9:00 pm to 1:00 am. The 12 mile road march is

traditionally the final station. The reason it is scheduled last is because the station is strenuous, all candidates can be processed at one time, and a significant period of rest is required after completion of the station. Other stations can only process one candidate at a time and require a longer group completion time. Where these conditions exist and space in the training area is available, the EFMB committee establishes station replications. Examples of stations with replications are the emergency medical treatment (EMT) and the survival training (ST) stations. Stations that have any limitation are first scheduled. The other stations are then scheduled by historical precedent.

Following completion of the draft schedule, the EFMB board estimates the required resources and the organization of each station. These estimates are made with the objective to complete the processing of all candidates in a group at a given station within the assigned time window. Personal knowledge and experience of the committee members and other individuals assigned to the Academy Brigade play a large role in developing these estimates. This process typically requires two days to complete.

At the same time these estimates are being made, the availability of resources (evaluators, helicopters, etc.) is determined. If a critical resource is available only during a specific time period, the schedule is modified to ensure all candidates process through that station during the available time.

After the exact scenarios for each station are fixed, the EFMB committee

conducts a trial run through the test site to certify the stations and to identify any bottlenecks or problems with the sequence and layout of the test site. The duration of the trial run is about five hours. The board members then make any necessary adjustments to the test site and schedule. No additional trial runs are made after these adjustments.

The scheduling process takes about six hours, but the work is not continuous since the site organization estimate and the results of the trial run are not available at one time. The total time required for the planning process is about 27 man hours with the trial run being the largest single time consuming event. As a result of the EFMB committee's estimate, availability of resources, and site certification, the schedule is completed. Figure 2 is an example final schedule.

G R O U P	DAY									
	1		2		3		4		5	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
A	*	*	ESW COM	DLN	LOC	EMT LOC NLN	ST	ST	RM	
B	*	*	DLN	ESW COM	LOC	ST NLN	EMT CPR	EMT CPR	RM	
C	*	*	DLN	COM ST	ESW	LOC NLN	EMT CPR	EMT CPR	RM	

* Site setup

DLN-Day land navigation

NLN-Night land navigation

ST-Survival training

ESW-Evacuation of sick & wounded

LOC-Litter obstacle course

EMT-Emergency medical training

RM-Road march

CPR-Cardiopulmonary resuscitation

COM-Communications

Figure 2. Final Schedule

If, during the conduct of the performance test, a bottleneck develops or a station is underutilized, but the group can still process through the station in the scheduled time, no changes are made. If a bottleneck develops and the group cannot process through the station in the scheduled time, the one and a half hour period for lunch and movement to the next station is used. If this additional time is still not enough and candidates begin to work significantly longer than 5:00 pm, adjustments to the schedule are made. The Academy Brigade does not attempt to add tasks or stations once the performance test has begun.

Figure 3 is a schematic of the Academy Brigade's organization and scheduling heuristic.

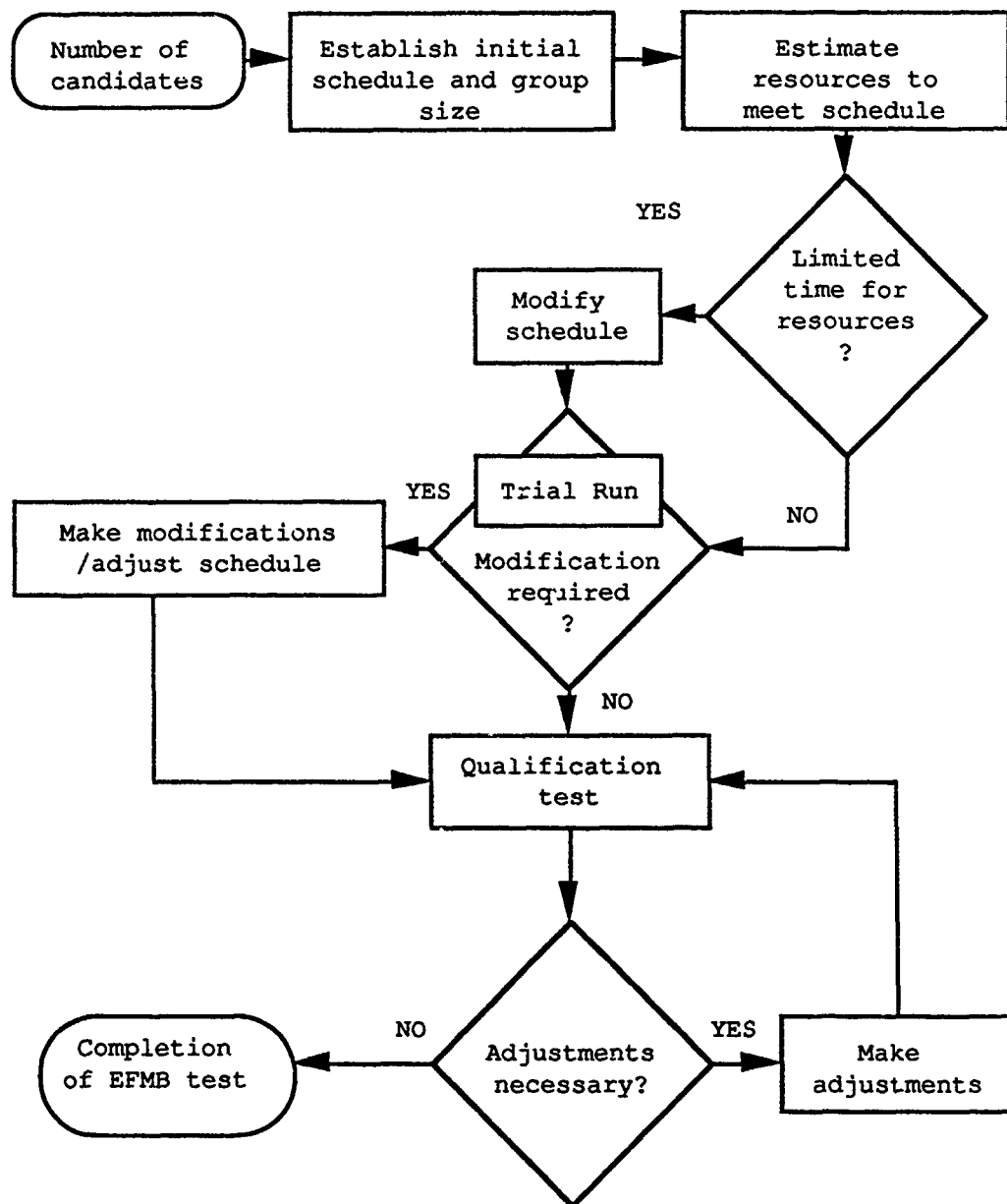


Figure 3. Academy Brigade Scheduling Heuristic

We now turn to a review of the applicable literature to gain insight to how this problem may be solved.

1.4 Literature Review

The EFMB problem may be viewed as a modified open shop scheduling problem with stochastic processing times and daily time windows. An open shop consists of several machines. All jobs are required to be processed on each machine, but the order is immaterial. This chapter reviews the literature on scheduling open shops and organizing stochastic assembly lines and highlights some of the major contributions that relate to the EFMB problem.

Gonzalez and Sahni [9] found that for non preemptive open shops, the problem of finding the optimum finish time when the number of machines is greater than 2 is NP-hard. The two machine problem is solvable, however, and they present an exact algorithm for the two machine deterministic job processing time open shop. The stochastic case is considered by Pinedo and Schrage [14]. They present scheduling policies for the two machine stochastic open shop model under different specific cases. One case is when the processing time on each machine is exponentially distributed and independent of the other machine and the service rate on both machines is the same. Another is when two jobs are available and one of them has not yet been processed on either machine. Specific rules for scheduling jobs in these cases are developed.

The stochastic case when the number of machines is greater than two is considerably more difficult. Unless the service time distribution is exponential (or Erlangian), and the system is very small in terms of both the number of

stations and the waiting buffer times between each station, it is not feasible to derive exact results about the output rates of production lines using queuing theory. In these cases, simulation has often been used.

The organization of stochastic assembly lines also has had considerable attention. Pinedo [11] studied how output processes depend on the sequence in which stations are set up. For m non-identical machines, an infinite number of customers, and infinite waiting room preceding each station, he found certain sequences more advantageous than others. He concludes that generally, in the case of infinite intermediate storage, in order to minimize the departure of each customer stochastically, stations with larger expected service times and smaller variances in the service times should be set up more toward the middle of the sequence and stations with shorter expected service times and larger variances should be set up more towards the beginning and toward the end of the sequence. Stations with other characteristics should be set up after the placement of these two more dominant categories.

Weeks [8] used simulation to study predictable due dates. He points out that previous research of flow shop and open shop scheduling has been largely concerned with the effects of local dispatching or sequencing decisions in machine constrained shops. The assignment of attainable or predictable due date lengths depends on expected job flow times which is a function of the required job processing time and expected job delay time. Previous research indicates job delay time depends on the dispatching and labor assignment procedures as well as

shop structure and congestion. The major objective of his research was to investigate the feasibility of using simulation to generate estimates of batch processing time to assign predictable due dates under conditions of varying shop structure and batch size. He found that due date performance tends to worsen as shop structure becomes more elaborate and complex.

Jacobs and Bragg [10], integrated shop conditions and job sequencing in lot-sizing decisions. Traditionally, one quantity is used to control the flow of work into a shop (release batches), to determine the number of units produced with a single operation set up (operation batches), and to move material between operations (transfer batches). Jacob and Bragg allow these quantities to vary. They designate the transfer batch as the basic planning unit and the release and operation batches as integer multiples of the transfer batch. Therefore, the jobs enter the production system together but are capable of being processed separately. Their procedure involves the queue being searched for jobs which use the current setup. If such a job is available, it is selected and starts processing immediately. If no jobs are available for the set up, the first job in queue is chosen and the machine is set up for that job. If the queue is empty, the next job to arrive at the machine is selected and the appropriate set up is made. Their simulation on a hypothetical production system resulted in significantly reduced flow times and a reduction in flow time variability. Another benefit they point out is the ability to dynamically manage capacity by allowing operation batch sizes to vary with the level of work load.

In the areas of assembly line design and balancing, El-Rayah [12] researched the output rates from balanced and unbalanced assembly lines. By using computer simulation, he confirmed that under variable station processing times, assigning stations having higher service times to the middle stations of an assembly line resulted in better output rates than those of balanced lines. This was also true when compared with the output rates from assembly lines unbalanced under other methods.

The literature reveals that the problem of organizing a shop with stochastic processing times is not an easy task. For problems having more than three stations, heuristics, analytical modeling using queuing theory, and simulation approaches have been employed. With these previous efforts considered, we now focus on the EFMB problem.

1.5 Statement of the Problem

In order to state the problem, we need to define the characteristics of a suitable EFMB performance test. On a daily basis, the groups processing through the test should work neither too late nor finish too early. This allows for a well organized EFMB performance test to conform to the planned schedule. However, often a group may work late or complete the day's scheduled events early. The sum of these late and slack times provides a good measure of an EFMB strategy to complete all tasks and meet the time window constraints. Therefore, we want to organize and schedule the EFMB performance test so it results in the smallest

sum of the total expected late and total expected slack times for all groups.

1.6 Why Simulation?

The number of parameters in the EFMB performance test makes it a difficult system to optimize. With its stochastic elements, it cannot be accurately described or evaluated analytically. Simulation, however, allows insight into the problem and has the capability to address the many parameters and the stochastic concerns. Using simulation allows performance estimates of the existing EFMB test under other projected operating conditions. It also provides an efficient method of comparing alternative strategies to see which one best meets a performance measure. Finally, experimenting with an EFMB performance test itself is not a feasible method to analyze different organizations and parameters for the test. Therefore, simulation is a good tool to use. The SLAM simulation language was chosen for this project because of its network approach, its ease of implementation, its ability to be modified using FORTRAN subroutines, and its capability to accommodate moderately large models.

1.7 Research Objectives

The following research objectives concerning the organization and scheduling of the EFMB performance test were defined for this report:

1. Collect data on the performance times for all stations and tasks for the Academy Brigade's EFMB performance test and estimate activity duration

parameters.

2. Develop, verify, and validate a simulation model for the Academy Brigade's EFMB performance test.

3. Present strategies for scheduling and organizing the EFMB test and measure each strategy's performance.

1.8 Methodology for the Research Effort

A data collection plan based on time study methods was first developed. Then, during the Academy Brigade's 1991 EFMB performance test, this plan was executed. Standard techniques of statistical inference were used on the results of the data collection effort to fit parameters and distributions, as appropriate, to the activity durations.

Next, using the insight gained from observing the performance test, a conceptual simulation model was developed. This model was then represented with a simulation program using the SLAM II simulation language. The simulation program was verified and validated using the Academy Brigade's EFMB performance test as the baseline. Finally, a number of strategies were developed with guidance from the Academy Brigade based on probable future EFMB site conditions. Modifications of these strategies were made to examine possible improvements. Guidelines for the conduct of the EFMB test were then developed under different conditions. In the following chapters, the results of this methodology are discussed.

Chapter 2

DATA COLLECTION

2.1 Purpose and Objectives of Data Collection

The Training Literature Division of the Academy of Health Sciences is the Army's proponent agency for the EFMB. This division writes and organizes the training circular governing the EFMB test. In this circular, some tasks have specific performance time standards for each item of the task, others have a maximum allowable time for the completion of a sequence of tasks, and still others have no set time limit.

This division maintains historical data on the results of previously conducted EFMB tests. The data is in the form of questionnaires and includes the number of officers and enlisted people who participated in the EFMB test, the type of unit to which they were assigned (Active Army, National Guard, Air Force, etc.), the number of people eligible for each specific prerequisite and qualification test station, and the number of people who passed. This information identifies the range of candidates taking the EFMB at particular sites and the number of candidates participating each year. Although this information sets some parameters for the EFMB test, no information on expected task completion times or task completion time variabilities exist. Therefore, in order to model the times to complete each station, it was determined that a time study was

required.

There were several objectives of the time study. The first was to collect as much data as possible on the time required to conduct each station and task. This included set up times, movement times between the tasks within each station, actual times to conduct the specific tasks, and the time to provide feedback to the candidate following his completion of the station (when applicable). Data was also desired on the time from a group's arrival at a station to the beginning of testing, and on the time required for organizing and assembling the group before leaving for the next station. Other objectives were to identify the type and quantity of resources required to conduct the performance test and to gain an in depth understanding of this system.

The remainder of this chapter includes a general description of time study with emphasis on the specific preparations for the EFMB study and the results of the study.

2.2 Time Study

Time study is a technique to establish an allowed time standard to accomplish a given task. It is based on the measured work content of the task while allowing for fatigue and for personal and unavoidable delays [Neibel, 6]. There are several methods used to conduct a time study: computerized data collection, standard data, fundamental motion data, work sampling, estimates

based on historical data, and the method applicable to this problem--the stopwatch time study. This discussion will focus on the time study principals of the stopwatch time study as applicable to the EFMB performance test.

2.3 Dividing the Stations into Elements

An important part of the time study is the identification of the elements in a given operation. When possible, the time study analyst should observe several cycles of an operation, identify the individual elements, and then proceed to conduct the study on the particular operation. In the EFMB time study, however, the duration of the test was limited so an attempt to identify the individual elements of each operation beforehand was made. The approach was to visualize a general scenario from the time a group of candidates arrived until they departed and to identify the elements in this sequence. This general scenario was then discussed with the EFMB committee representative familiar with the specific content of each station. This was accomplished by personal interviews during the test run conducted for the Academy Brigade's 1991 EFMB performance test. Modifications were then made to the general scenario and the elements of each station along with their proper sequence were identified.

To establish consistency between readings, it is necessary to identify the end points of each element under study. These terminal points can be associated with a specific action, a specific sound, or both. For instance, the terminal point for the litter obstacle course was when the litter team performing the course

crossed the finish line. For elements in sequence, the terminal point for one element is its completion, and is also automatically the beginning point for the succeeding element. Terminal points were established for each timed task within all stations of the EFMB performance test.

2.4 Time Study Forms and Equipment

The minimum equipment required for a time study is a stopwatch, time study forms, a clipboard, and a pocket calculator. There are several types of stop watches, both manual and electric. For the EFMB study, manual, digital display stopwatches were used. The precision of these watches was to a full second. Accuracy beyond this point was not deemed necessary. Other equipment included clipboards, clear plastic cover sheets and plastic bags (for inclement weather recording), and time study forms. A backup method for recording times was a dictation recorder.

Draft time study forms were developed from the EFMB task list, the EFMB training circular, and the elements of each station identified through the conversations with representatives of the EFMB committee. Finally, the forms were completed and standardized according to the format in [6]. Figure 4 is an example.

SCENARIO:	Litter Obstacle Course			DATE:	5-Sep-91
			Movement to	Completion of	Completion of
SUBTASK (Element)		Instructions	starting point	1st obstacle	station
NOTES	CAND. #	T R	T R	T R	T R
start 7:30:00	1	:36:42	:36:45	:38:20	:01:50
start 8:20:00	2	:25:32	:25:40	:27:10	:55:08
start 9:05:00	3	:12:43	:12:56	A	M
	4				
SUMMARY					
ELAPSED TIME					
TOTALS					
# OBS					
AVE T.					
FOREIGN ELEMENTS			REMARKS:		STUDY
		T R			STARTED
A--Candidate	END	:18:24			AM 7:30:00
injured leg on	BEGIN	:13:46			PM
1st obstacle					
B - -	END				STUDY
	BEGIN				FINISHED
C - -	END				AM 11:23:00
	BEGIN				PM
D - -	END				OVERALL TM
	BEGIN				MIN 3:53:00

Notes: R-Stopwatch reading
T-Elapsed time

Figure 4. Example Time Study Form

2.5 Methods of Time Study

The two techniques for recording time observations while taking a time study are the snapback method and the continuous method. When using the snapback method, the time study analyst reads the time at the termination point of an observed element and then snaps the stopwatch hands back to zero. This procedure is used throughout the study. Advantages of this method are that the time for each element is measured directly and there is no need for successive subtractions between readings to obtain the times for each activity. Also if an element is performed out of order, no special action is required to record the time of the element. There are also disadvantages to this method. The timing of very short successive events is inaccurate since the time elapsed when the hands are being reset is not recorded (not a big problem with today's electric stopwatches). The record of discrepancies during the time study may not be complete (i.e. not recording events performed out of order or delays between events). Also, there can be no verification between the overall time elapsed and the sum of the element stopwatch readings as the continuous method provides.

The continuous method allows the stopwatch to run for the entire study. The study analyst reads the hands at the termination point of an element as the hands are moving. A stopped hand can be read as continuous time is being recorded on many stopwatches or a specific value can be read on many digital watches. Advantages of this method are that a complete record of the elapsed time for a specific operation is recorded. Measuring elements of short duration is also

better suited to this method. The predominant disadvantage is the additional successive subtractions that are required between element time readings to obtain element duration times. However, modern computer spreadsheets have made this task trivial. This method was chosen for the EFMB time study due to its ease of implementation for time readings and the method's ability to capture all the information about the operation under study.

A time study is usually taken over a designated number of cycles on the actions performed by a representative worker on a specific workstation. The study of the EFMB is a modification as the workers (candidates) rotate through the stations. The cycle measurements are therefore dependent on the characteristics of the particular candidate. While the objective of a time study is to establish a time standard for performance of a given task, this study is to determine the time duration and variability that it actually takes to perform a task.

For an EFMB station with only one task, the continuous time study method is conducted as described above. However, for a station consisting of several tasks sequenced as a scenario for the candidate, the time study analyst must move along with the candidate, maintaining a position that enables him to observe the terminal points of the tasks. The procedure for continuous time study will then have a time under which no observations are made as the time study analyst moves from the end of the scenario to the starting point and begins observing a new candidate. The example EFMB time study form (Figure 4) shows the

readings for this situation.

2.6 Contingency Planning for Difficulties

Time study plans should include actions to be taken if difficulties occur during the conduct of the study. One of these possible difficulties is when the time study analyst misses a reading. In this case, a letter 'M' is placed in the time reading cell for the element missed on the time study form. Other difficulties may occur by intentional changes in the order of work or an unavoidable delay.

Three classes of interruptions are personal interruptions, fatigue, and unavoidable delays. Personal interruptions are changes in the order of work due to the worker going to the rest room, getting a drink of water, etc. Fatigue is a pause to break the monotony of the work cycle or to recover after a particular physical or stressful task. Unavoidable delays are caused by machine failure, tool breakage, or interruptions by a supervisor. These interruptions in the operation cycle are referred to as foreign elements in [6]. These foreign elements are designated by a letter in the elapsed time cell of the time study form for the element and a corresponding explanation is made in the appropriate section of the form. Figure 4 illustrates both the entries for a foreign element and for a missed time reading.

2.7 Computing the Time Study

The steps taken in computing the time study after it has been taken include the following:

1. Make subtractions of consecutive readings to obtain the activity time for each element.
2. Circle and discard all foreign or abnormal values where an assignable cause is evident.
3. Summarize the remaining times for the specific elements.
4. Determine the mean of the observed activities for each element.

2.8 Allowances

The time readings of any time study are taken over a relatively short period of time. To determine the average time of any event under study, the time study analyst removes the effects of foreign events and other discrepancies. This results in an estimate of the time required for a particular activity without any allowances for unavoidable delays or other legitimate lost time during the activity cycle. Allowances for personal delays, fatigue, and unavoidable delays must then be made to adjust the activity times.

Two methods frequently used to develop standard allowance data are the production study and the work sampling study. Both of these methods rely on observing an activity over a long period or taking many random observations of

an activity to determine the state of that activity at a particular random time. The production study requires a detailed analysis of the particular activities at a workstation and the classification of these activities as personal delays, fatigue, unavoidable delays, or productive activities. The work sampling study requires unannounced observations of the activities at a workstation over a long time frame and the classification of the activities in the same manner as the production study. By these methods, an allowance for unproductive time is determined for the workstation.

These time study allowances are based on an observed worker at a given work station. This report is concerned about different candidates at specific performance stations. As each candidate has the opportunity to take care of personal delays and rest both before and after his conduct of the specific performance station, allowances for these factors are assumed negligible for the EFMB time study. Likewise, unavoidable delays should be practically nonexistent or the candidate may not be able to meet the standards for the particular station. It is therefore assumed that the candidate or the evaluator will not be interrupted while performing at a given station. For these reasons neither of the allowance methods is appropriate for the EFMB time study and no allowances were made.

2.9 Conduct of the Time Study

The time study was conducted from September 4 to September 8, 1991 at Bullis Training Area, Fort Sam Houston, Texas. The significant points concerning

the conduct of the study are presented. The study results are then discussed.

Although personal coordination about each station and task occurred with a knowledgeable member of the EFMB planning committee before the beginning of the performance test, within some stations changes to the sequence of the tasks occurred. This was not a problem as blank time study forms were available and the time study analyst met with the person in charge of each station before testing began. Modifications to the time study forms were made as appropriate.

Some stations were set up so many observations could be made by the time study analyst. For example, the day land navigation course, night land navigation course, and the 12 mile road march had specific starting locations and times and had a single specific ending location that the time study analyst could position himself to collect all available data. Other stations and tasks were dispersed and the time study analyst had to move quickly from station to station and from task to task in order to obtain performance readings. At these stations, the goal was established to obtain at least three observations per station and then use any remaining time to get additional observations.

The organization of and the required resources for each station was recorded. Particular attention to the flow of candidates through each station was made. Details about the queues for each station and task, the number of identical tasks within a station, critical resources and sequencing, and movement times between stations and tasks were also observed and recorded. A specific discussion

of the significant aspects of each station is presented in the simulation program section of this report.

2.10 Results

The schedule shown as Figure 2 was used by the Academy Brigade for this performance test. Two tasks in the evacuation of sick and wounded station caused a significant bottleneck. Both required loading and unloading casualties--one using a two and one half ton truck and the other using a helicopter. This delay caused a schedule modification. The survival training and emergency medical treatment stations had two and four station replications respectively, but still resulted in a significant waiting period before the candidates could pass through. Since only 44 candidates underwent the performance qualification test, the time available was sufficient, when adjusted, to complete these stations before the 12 mile road march on the last day of the test.

Upon completion of data collection, the time study was calculated. The day land navigation, night land navigation, and road march stations had several observations (36-42). The completion times for these stations were analyzed using a statistical software package. The normal distribution resulted in the best theoretical fit. The number of observations for the other stations were significantly less (3-5). Although the distribution of these activity durations could not be determined, it was assumed they were normal for the purpose of defining variation in the activity times for later use in sensitivity analysis. For

the simulation analysis, expected value was used. The distributions and parameters are listed in Tables 1 through 3. These parameters include all activities associated with the particular station or task (i.e. initial instructions, conduct, and feedback as applicable). Since the communications (COM) and evacuation of sick and wounded (ESW) stations were performed as a series of separate tasks with separate designated queues, estimates for these task durations are listed separately.

EFMB STATION DURATION DATA (HRS)			
Station	Observations	Mean	Std Dev
EMT	3	0.76	0.10*
CPR	5	0.04	0.01*
LOC	3	0.53	0.07*
NLN Normal	42	2.15	0.60
DLN Normal	42	2.11	0.41
RM Normal	36	2.74	0.16
ST			
1st 3 Tasks	4	0.15	0.03*
Remain Tasks	4	1.18	0.13*

* Standard deviation estimates only used for sensitivity analysis

Table 1. Estimated EFMB Station Duration Data

STATION: ESW Task Duration Data (HRS)			
TASK	Observations	Mean	Std Dev*
Pistol Belt Carry	3	0.10	0.03
Load & Unload 2 1/2 ton trk	3	0.19	0.01
Improvised Litter	3	0.09	0
Load & Unload a Front Line Ambul	3	0.12	0.02
Load & Unload a 1 1/4 ton trk	3	0.15	0.03
Load & Unload Helicopter	3	0.15	0.02
Fireman's Carry	3	0.03	0.01
Four Hand Seat Carry	3	0.02	0

* Standard deviation estimates only used for sensitivity analysis

Table 2. Estimated Duration of ESW Tasks

STATION: COM Task Duration Data (HRS)			
TASK	Observations	Mean	Std Dev*
Request Medivac	3	0.12	0.07
Enter a Radio Net & Auth	3	0.11	0.01
Prepare & Operate PRC_77	3	0.06	0
Install & Operate TA-312	3	0.04	0.01
Sum of PRC-77 & TA-312		0.10	0

* Standard deviation estimates only used for sensitivity analysis

Table 3. Estimated Duration of COM Tasks

Chapter 3

THE MODEL

3.1 Conceptual Model

The present method of operation for the Academy Brigade's EFMB can be conceptually portrayed as in Figure 5. The groups independently process through all stations except the night land navigation and the road march stations. Generally, for these two stations, all groups process through at the same time. Each station consists of one or more tasks and the critical resources for each station are modelled. These critical resources are usually the evaluators and the associated training materials the candidate requires to complete the task. The emergency medical treatment station and the cardiopulmonary resuscitation task are scheduled together and candidates process through each as the resources become available. The road march is scheduled by itself after all other tasks are completed.

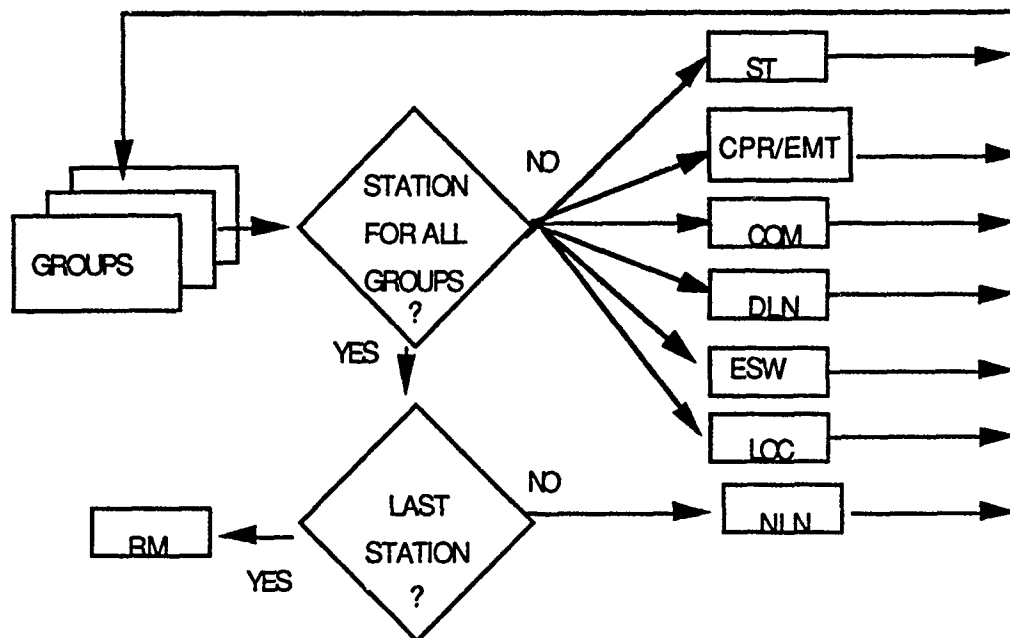


Figure 5. Conceptual Model

3.2 Assumptions

Based on the physical limitations of Bullis Training Area, preferences of the Academy Brigade's Training staff, and precedent for daily training duration, the following assumptions are made. The general set up and location of each EFMB station will be the same as the 1991 EFMB performance test. The Academy Brigade will continue to schedule the road march for all the groups at the same time and will also continue to schedule it as the last station. For the night land navigation course, if the total number of candidates is 60 or less, they will all be scheduled at the same time. If the total is more than 60, the night land navigation station will be scheduled by group on separate nights.

Movement times between stations are negligible except for the litter obstacle course and the land navigation courses. The movement times to these stations are estimated at 20 minutes (litter obstacle course) and 30 minutes (day and night land navigation courses). Within stations, the movement times between tasks in the survival training station and in the litter obstacle course station are significant and are included in the station parameters. Finally, the daily training schedule will start at 7:30 am and end at 5:00 pm (except on scheduled night land navigation days).

3.3 Simulation Program

The EFMB simulation program consists of a SLAM program and FORTRAN subroutines. The SLAM program is divided into distinct functional modules. The program has a module for statistic collection, for routing, and for each station. The FORTRAN subroutines are used to initialize the SLAM program with a specific instance of interest, interact as necessary with the SLAM network for activity durations and statistic collection, and generate final statistics and reports.

3.3.1 Initialization Subroutine

The purpose of the initialization subroutine is to obtain the parameters of the desired simulation instance. Inputs include the number of groups, the number of candidates per group, the daily training duration, the number of specific station and task replications, and the proposed schedule. SLAM II global

variables are used for the number of groups, the number of candidates per group, counting indices, and the daily training duration. An array is used for the group schedules. The number of specific stations and tasks is established by setting the capacity of the associated resource. These parameters are then passed to the SLAM program. In the SLAM program, all candidates are placed in the enter node, assigned a start time, formed into their groups, and processed through the station routing module.

3.3.2 General Simulation Network

The groups process through each station according to their schedule. Each station consists of several tasks and movement times between the tasks as applicable. The required resources are set busy while a candidate executes the particular task or activity. This process continues until all candidates within a group complete all tasks. The group then proceeds to a series of conditional branches that determine if late or slack statistics should be collected. In these conditional branches schedule feasibility and the end of each day's training is also checked. A description of the significant aspects of each station is included in the modules section.

A user function is used to assign duration times to the EFMB activities, to ease statistics collection, and to stop an infeasible EFMB strategy. This function is called as necessary by the SLAM program.

3.3.3 Statistics

All times associated with this model are in hours. Statistical results over 30 simulated EFMB tests are collected for average test completion time, average late time, average number of groups late, average slack time, average number of groups having slack time, average station completion time, and average waiting times at each station or task. Additionally for the final run, a schedule analysis of late and slack times is provided as well as the SLAM summary report. The desirable characteristics of a well organized EFMB test include no significant bottlenecks, a small sum of the total average late and total average slack times, a maximum night land navigation course completion time less than 6 hours, and a maximum time in system less than 120 hours.

3.3.4 Modules

In the day land navigation (DLN) module, the candidates have 30 minutes to get their maps and practice on a 100 meter pace course before moving in groups of ten (in 15 minute intervals) to start the land navigation course. Statistics are collected on group completion times. The candidates are then batched into their groups and are processed through the control checks and routing module. The night land navigation (NLN) module is basically the same as the day module.

At the survival training (ST) station, candidates process through one

after another. Between candidates is a delay time equal to the preceding candidates completion time for the first three stations. The number of candidates processing through at one time is limited by the number of evaluators working at the station. Two resources are used to model this effect. The first resource models the delay and this resource is only set free if the second resource is available. This limits the number of candidates who can concurrently perform the station. After all candidates have completed the survival training station, statistics are collected by group. Then the candidates are batched into groups, and are processed through the control checks and routing module.

The emergency medical treatment (EMT) module includes the cardiopulmonary resuscitation (CPR) station. Upon arrival, one candidate for each EMT station replication begins that test. The others process through the CPR station. Attributes are flagged when each candidate has accomplished each of these two tasks. Since the CPR task's duration is short, it is not modelled as a resource. When all candidates complete these two tasks, data collection, batching, and movement to the control checks and routing module occur.

The litter obstacle course (LOC) requires four candidates to perform the task as a team. An attribute is assigned a negative one for the last candidate in the group to allow the last team to proceed should the group size not be an increment of four. Each team processes through the station one at a time. After all candidates have completed the station, data collection, batching, and movement to the control checks and routing module then follow.

In the communications (COM) and evacuation of sick and wounded (ESW) modules, candidates proceed to their initial task with an equal probability of selecting any task in the station. For the communications station, attributes are flagged to show that each candidate has performed each task. Both tasks covering radio operations are performed at the same sub-station. The ESW station's tasks are set up one after another and after the candidate's initial task, he performs the remaining tasks in a predetermined order. Balking, jockeying, or different orderings are considered negligible. Data collection, batching, and routing follow the standard order.

The road march (RM) module starts all candidates scheduled for a particular night at one time. Data collection, batching, and movement follow in the same manner as the other stations.

After all stations have been completed, candidates exit the system and the FORTRAN output subroutine compiles the statistics. In Appendix B, the simulation program variables and resources are listed.

3.4 Verification and Validation

In addition to using the output reports, the computer simulation program was verified by using the debugging facilities in the SLAM simulation language, by adding additional collect nodes throughout the SLAM network, and by putting many write statements in the FORTRAN subroutines. This process verified that

the initialization parameters were correctly set, that the groups and candidates processed through the simulation as modelled, that the SLAM network interacted with the FORTRAN subroutines to obtain activity durations and to ease statistic collection, that the logic throughout the program operated as intended, and that an accurate output report was provided.

The validation of the simulation program was accomplished throughout the simulation study. The conceptual model and simulation program modules were examined and approved by the president of the EFMB board. Also, the simulation program was validated using the Academy Brigade's 1991 EFMB performance test as the baseline. Then, in conjunction with the Academy Brigade training staff, pilot simulation runs were performed and the results validated through their experience with the conduct of the EFMB at Bullis Training Area. By examining group station completion times, waiting times at the modelled tasks and stations, specific group late and slack time information, and average EFMB completion time, it was agreed that the model had predictive value and was useful as a tool in organizing future performance tests.

Chapter 4

DESIGN OF EXPERIMENTS

The purpose of the experimental design for the EFMB is to examine strategies for scheduling and organizing the performance test and to compare these strategies based on the sum of the total average late time and total average slack time.

4.1 Factors

Based on conversations with the Academy Brigade's test scheduler, several factors and their levels were established to define possible future EFMB performance test strategies. The factors are number of candidates, number of groups, testing schedule, three critical tasks within the ESW station, and EMT and ST station repetitions. The tasks within the ESW station are loading and unloading patients from a two and one half ton truck, from a quarter ton truck, and from a helicopter. Due to space limitations, the EMT and ST stations are the only stations that can be replicated. The ranges of these factors were determined by the Academy Brigade's test scheduler and reflect both space and resource limitations. Table 4 lists all the experimental factors, with the exception of the test schedule, and their respective ranges of interest.

FACTORS	HIGH	LOW
Number of Candidates	180	60
Number of Groups	4	3
Task Duplicates (ESW)		
2 1/2 ton	3	1
1/4 ton	2	1
Helicopter	2	1
Station Repetitions		
ST	3	1
EMT	6	4

Table 4. Experimental Factors

Several testing schedules were also considered. They are shortest stations first, longest stations first, shortest first-separation, longest first-separation, and day packing. The duration of the stations are based on expected value. The shortest stations first schedule assigns to the beginning of each group's schedule the first shortest station available, then the next shortest, etc. beginning with the first group. No two groups are scheduled for the same station in the same schedule position.

The longest stations first schedule follows the same logic as described above except with the schedule beginning with the longest station. Shortest first-separation attempts to schedule the shortest stations first and also to allow for as much separation between successive groups scheduled for the same station as possible. The longest first-separation schedule follows similar logic. The day

packing method schedules paired stations for each day, with the intent to fill each day as completely as possible.

In order to obtain approximately normally distributed statistics for the EFMB strategy, 30 simulation runs were conducted.

4.2 Performance Measure

The performance measure for the EFMB strategy is the sum of the total average late time and total average slack time over the 30 simulation runs. It is calculated by taking the average late time multiplied by the average number of groups late plus the average slack time multiplied by the average number of groups that finish early.

4.3 Methodology

The experiment was first conducted for the 60 candidate, three group, EFMB test. Initially, the best resource levels were determined. A two level one quarter fraction of the 2^{5-2} fractional factorial design was used for this experiment [Montgomery, 15]. The factors in the design matrix were the task duplicates for the ESW station and the ST and EMT station repetitions. The high and low levels in Table 4 correspond to the two levels for each factor in the design matrix. The schedule used was the Academy Brigade's 1991 EFMB schedule (PMO).

Using the best resource setting, the different schedules were then analyzed. After the best schedule was determined, it was examined to see if any schedule modification could be made to improve the solution. Upon determining the best modified schedule, the resource levels were checked to confirm the selection of the resource setting. Finally, a sensitivity analysis, assuming normality for all activity distributions and using the parameters obtained through the time study, was performed. The knowledge gained from the results of the 60 candidate, three group test was then applied to determine an appropriate starting point for the 60 candidate, four group test and the 180 candidate test problem. The results of this design, as well as the specifics of the procedure used to improve an EFMB strategy, follow in the next chapter.

Chapter 5

RESULTS AND CONCLUSIONS

This chapter presents the results of the EFMB test simulation study in three parts. The first part describes the results with 60 candidates, and the second part describes the results with 180 candidates. The third part provides a short conclusion. The results of the simulation study are summarized in this chapter. Additional strategies and a comprehensive listing of all results are in Appendix E.

5.1 60 Candidate EFMB Test Results

The analysis of the EFMB test began with determining the resource strategy that resulted in the smallest sum of the total average late and slack times. Using the fractional factorial design referenced in the preceding chapter and the Academy Brigade's 1991 test schedule, the best resource setting is FMO5.

Although FMO5 is the best resource setting using the sum of total average late and total average slack times as the performance measure, the time savings must also be weighed against the net resource costs. For example, FMO5 estimates three hours less average total late time than FMO4, but requires different resources (two more 2 1/2 ton trucks, one more helicopter, and one less 1 1/4 ton truck with associated training materials and evaluators). If the additional net resource costs are disproportionate to the time benefits gained, then it would not be economical to commit the additional resources to the test.

For this analysis, it was assumed that FMO5 was reasonable in terms of the time-resource trade off, and it was then used as a starting point to examine schedules using three and four groups. Table 5 summarizes the results of this experiment.

STRATEGY NAME	AVERAGE TOTAL (HOURS)			RESOURCE LEVEL				
	LATE TIME	SLACK TIME	TOTAL	A	B	C	D	E
PMO	10.076	13.256	23.332	1	1	1	2	5
FMO1	3.550	17.138	20.688	3	2	2	3	6
FMO2	24.832	8.920	33.752	1	2	2	1	4
FMO3	20.856	11.826	32.682	3	1	2	1	6
FMO4	8.189	12.404	20.593	1	1	2	3	4
FMO5	5.188	12.570	17.758	3	2	1	3	4
FMO6	23.858	11.621	35.479	1	2	1	1	6
FMO7	21.764	9.007	30.771	3	1	1	1	4
FMO8	7.866	16.563	24.429	1	1	1	3	6

Schedule for the Resource Problem (PMO) Resource Codes

7,6,1,10,5,4,2,20,3,30,8,9

1,7,6,10,5,3,2,20,4,30,8,9

1,6,3,10,7,5,2,20,4,30,8,9

A-2 1/2 ton truck task (ESW)

B-Helicopter task (ESW)

C-1 1/4 ton truck task (ESW)

D-number of survival
training lanes

E-number of emergency
medical treatment lanes

Table 5. Results of Resource Analysis

The best schedule using three 20 candidate groups was SFMO6R, and the best schedule using four 15 candidate groups was BFMO9D. The total average late and slack times are 13.231 and 3.844 respectively. Neither of these two schedules was an initial schedule to be considered. Instead, upon examining the results of the initial schedules, it was determined improvements could be made by following some simple guidelines.

The procedure for improving an EFMB strategy involves finding a schedule containing slack and late times for at least one group. Then, using the average group completion times for each station, examine whether changing stations between days might improve the solution. Next, consider possible side effects of these changes. For example, an adverse side effect could be a schedule conflict with another group or additional waiting time due to another group being

scheduled before or after the proposed station position and unacceptable overlapping occurring. If the improvement still appears possible, make the schedule changes and conduct the simulation. This procedure is repeated as necessary until no further schedule related improvements can be made. Finally, examine whether a change in the resource levels would result in a better performance measure, and if appropriate make the adjustment and conduct the simulation. This procedure is presented in Appendix D.

The best schedules for the 60 candidate test were determined by applying the improvement procedure to the initial schedule with the best performance measure. The procedure was applied to the present method of operation (SPMO) for the three group problem and to the shortest-first separation schedule (BFMO4) for the four group problem. The three group problem required five iterations of the improvement procedure. The four group problem first required an initial schedule adjustment to a three day schedule. Then four iterations of the improvement procedure were performed. A better resource level was found for the three group schedule while resource level FMO5 remained the best for the four group problem. Tables 6 and 7 list the results for the three and four group problems.

The codes listed below are used for Tables 6 through 9:

<u>SCHEDULE CODE</u>	<u>EVENT</u>	<u>RESOURCE CODES</u>
1	Day Land Navigation	A-2 1/2 ton truck tasks (ESW)
2	Night Land Navigation	B-Helicopter tasks (ESW)
3	Survival Training	C-1 1/4 ton truck tasks (ESW)
4	Emergency Medical Treatment & CPR	D-number of ST stations E-number of EMT stations
5	Litter Obstacle Course	
6	Communications	
7	Evacuation of Sick and Wounded	
8	Road March	
9	All Stations Complete	
10-40	End of Day One thru Day Four Training	

STRATEGY	AVERAGE TOTAL (HOURS)			
NAME	LATE TIME	SLACK TIME	TOTAL	SCHEDULE
SPMO	5.188	12.57	17.758	7,6,1,10,5,4,2,20,3,30,8,9
				1,7,6,10,5,3,2,20,4,30,8,9
				1,6,3,10,7,5,2,20,4,30,8,9
SFMO6	3.767	12.579	16.346	7,6,1,10,5,4,2,20,3,30,8,9
swap 3&7				1,7,6,10,5,3,2,20,4,30,8,9
group 3				1,6,7,10,3,5,2,20,4,30,8,9
SFMO6A	1.758	13.181	14.939	7,6,1,10,5,4,2,20,3,30,8,9
swap 1&5				5,7,6,10,1,3,2,20,4,30,8,9
group 2				1,6,7,10,3,5,2,20,4,30,8,9
SFMO6B	0.829	13.509	14.338	7,6,1,10,5,4,2,20,3,30,8,9
swap 5&1				5,7,6,10,1,3,2,20,4,30,8,9
group 3*				6,5,7,10,3,1,2,20,4,30,8,9
SFMO6C	0.484	12.978	13.462	7,6,5,10,4,1,2,20,3,30,8,9
swap 5&1				5,7,6,10,1,3,2,20,4,30,8,9
group 1*				6,5,7,10,3,1,2,20,4,30,8,9
				RESOURCE LEVEL
				A B C D E
SFMO6R	0.507	12.725	13.231	1 1 2 3 4

* includes within day station position change to avoid schedule conflict

Table 6. Results of three 20 Candidate Group Schedules

STRATEGY	AVERAGE TOTAL (HOURS)			
NAME	LATE TIME	SLACK TIME	TOTAL	SCHEDULE
BFMO4	0.906	28.219	29.125	6,5,10,7,4,2,20,3,1,30,8,9
				7,4,10,3,1,2,20,6,5,30,8,9
				3,1,10,6,5,2,20,7,4,30,8,9
				6,5,10,1,3,2,20,7,4,30,8,9
BFMO7	7.571	0.926	8.497	7,6,1,10,5,4,3,2,20,8,9
change to				1,7,5,10,6,3,4,2,20,8,9
3 day				5,6,7,10,3,1,4,2,20,8,9
schedule				6,5,1,10,4,7,3,2,20,8,9
BFMO8	4.860	1.464	6.324	7,6,1,10,5,4,3,2,20,8,9
swap 4&6				1,7,5,10,6,3,4,2,20,8,9
group 3				5,4,7,10,3,1,6,2,20,8,9
				6,5,1,10,4,7,3,2,20,8,9
BFMO9	3.201	2.308	5.508	7,6,3,10,5,4,1,2,20,8,9
swap 1&3				1,7,5,10,6,3,4,2,20,8,9
group 1				5,4,7,10,3,1,6,2,20,8,9
				6,5,1,10,4,7,3,2,20,8,9
BFMO9A	3.130	2.236	5.366	7,6,3,10,5,4,1,2,20,8,9
swap 5&4				1,7,4,10,6,3,5,2,20,8,9
group 2				5,4,7,10,3,1,6,2,20,8,9
				6,5,1,10,4,7,3,2,20,8,9
BFMO9D	2.322	1.528	3.844	4,6,3,10,7,5,1,2,20,8,9
swap 4&7				1,7,4,10,6,3,5,2,20,8,9
group 1*				5,4,7,10,3,1,6,2,20,8,9
				6,5,1,10,4,7,3,2,20,8,9

* includes within day station position change to avoid schedule conflict

Table 7. Results of four 15 Candidate Group Schedules

A sensitivity analysis, using the task duration variability estimates, was performed. The resource problem and the best schedules for both group strategies were analyzed. The sensitivity analysis for the resource problem

resulted in FMO5 still being the best resource setting. The sensitivity analysis for the best schedule in each group strategy also resulted in the same schedule having the best performance measure (i.e. SFMO6R for the three group strategy and BFMO9D for the four group strategy).

The average CPU time used for a three group, 60 candidate simulation and for a four group, 60 candidate simulation was 67.7 seconds and 61 seconds respectively.

5.2 180 Candidate EFMB Test Results

In order to obtain an initial estimate for some of the group station times, the best schedule and resource level for the three and four group 60 candidate strategies were used as starting points. The results indicated that most stations would take longer than the planned daily training duration (9.5 hours). In order for the simulation to remain feasible, however, two stations had to be scheduled on two days to meet the 120 hour test duration requirement. Using the average group station time estimates, the two double station days were scheduled by pairing the first longest station with the first shortest one and by pairing the next longest station with the next shortest one. When this simulation was conducted for three 60 candidate groups using resource setting FMO5, the results show no slack time with an average of 3.88 hours of late time per day. Since there was no slack time, no improvement could be made to the order of the stations in the schedule. The resource level could improve the performance measure, however, and by setting all the resources to their highest available levels (resource setting FMO1), the total average sum of group late and slack times decreased to 41.474 from 53.781. This strategy resulted in some slack time, but the slack time was associated only with the EMT station and no improvement could be made through the improvement procedure. Table 8 summarizes the results for the three 60 candidate group strategies.

STRATEGY NAME	AVERAGE TOTAL (HOURS)			RESOURCE LEVEL				
	LATE TIME	SLACK TIME	TOTAL	A	B	C	D	E
G3FM1	35.353	5.27	40.623	3	2	2	3	6
G3FM4	53.781	0	53.781	1	1	2	3	4
G3FM5	46.582	0	46.582	3	2	1	3	4
G3NEW	35.33	0.71	36.04	3	2	2	3	5

Schedule for Three Group 180 Candidate Problem

1,7,10,5,6,20,4,2,30,3,40,8,9
 5,6,10,4,2,20,3,30,1,7,40,8,9
 3,10,1,7,20,5,6,30,4,2,40,8,9

Resource Codes

A- 2 1/2 ton truck tasks
 B- Helicopter tasks
 C- 1 1/4 ton truck tasks
 D- number of survival training lanes
 E- number of emergency medical treatment lanes

Table 8. Results of three 60 Candidate Group Schedules

Using the same pairing technique explained above, a four group schedule was made. This schedule was then simulated with resource level FMO5 (strategy G4FM5). This strategy resulted in a performance measure of 23.042 hours.

STRATEGY NAME	AVERAGE TOTAL (HOURS)			RESOURCE LEVEL				
	LATE TIME	SLACK TIME	TOTAL	A	B	C	D	E
G4FM1	16.298	13.533	29.831	3	2	2	3	6
G4FM4	28.893	1.351	30.245	1	1	2	3	4
G4FM5	21.691	1.351	23.042	3	2	1	3	4
G4NEW	16.312	1.373	17.685	3	2	2	3	4

Schedule for Four Group 180 Candidate Problem

1,7,10,4,2,20,3,30,5,6,40,8,9
 5,6,10,1,7,20,4,2,30,3,40,8,9
 3,10,5,6,20,1,7,30,4,2,40,8,9
 4,2,10,3,20,5,6,30,1,7,40,8,9

Resource Codes

A- 2 1/2 ton truck tasks
 B- Helicopter tasks
 C- 1 1/4 ton truck tasks
 D- number of survival training stations
 E- number of emergency medical treatment stations

Table 9. Results of four 45 Candidate Group Schedules

No improvement could be made to this schedule since all the slack time was associated with the day the EMT station was scheduled. Any change of stations would only result in a change of day for the slack time.

This strategy was then checked with resource levels FMO4 and FMO1. By examining these results, it was found that adding one additional 1 1/4 ton task to the ESW station produced the best EFMB strategy (G4NEW). These results are summarized in Table 9.

A sensitivity analysis was also performed on the best schedule and on the resource levels for the three and four group strategies. For the three group schedule, the sensitivity analysis resulted in the performance measure increasing from 36.040 to 37.705, an increase of 1.665 hours. The resource level did not change. The total average sum of the late and slack times for the four group schedule was 18.999 (an increase of 1.314 hours) under the stochastic conditions and the resource level remained the same.

The average CPU time used for a three group 180 candidate simulation and for a four group 180 candidate simulation was 210.9 seconds and 206.4 seconds respectively.

5.3 Conclusions

This study demonstrates the capabilities of simulation in analyzing and identifying schedules and resources to arrive at an estimate of the total sum of the average group late and slack times for an EFMB performance test. For candidate levels of 60 and 180, strategies were found that efficiently arrive at a "best" solution for three group and four group schedules. In order to refine the model, additional data collection studies on the activity durations, instruction times, and movement times could be performed.

The model and results are being used by the Academy Brigade both as a historical document on the conduct of the EFMB at Fort Sam Houston and as a planning tool for future EFMB tests.

Appendix A

EFMB PREREQUISITES AND PERFORMANCE TEST TASKS

The two paragraphs below list the prerequisite training required of each candidate and the tasks that comprise the performance test.

A.1 Prerequisites

1. Army physical fitness test
2. Weapons qualification
3. Commander's recommendation

A.2 Performance Test Tasks

1. Comprehensive written test
2. Land navigation
 - a. Day compass course
 - b. Night compass course
3. Communications
 - a. Install and operate a field telephone
 - b. Prepare and/or operate FM radio
 - c. Enter radio net and authenticate
 - d. Prepare and transmit an evacuation request
4. Survival
 - a. Put on M17 series protective mask with hood
 - b. Decontaminate skin
 - c. Put on protective clothing
 - d. Decontaminate individual equipment and exchange MOPP gear
 - e. Replace filters in M17 series protective mask
 - f. Store M17 series protective mask
 - g. Camouflage self and equipment

- h. Reduce stoppage of an M16 series rifle
 - i. Disassemble/assemble M16 series rifle
- 5. Forced Road March
- 6. Emergency Medical Treatment
 - a. Survey patients and perform triage
 - b. Apply a tourniquet
 - c. Treat a chest wound
 - d. Treat an abdominal wound
 - e. Apply a pressure dressing
 - f. Apply a field first aid dressing
 - g. Splint a suspected fracture
 - h. Treat for shock
 - i. Apply a dressing to a head wound
 - j. Initiate an IV infusion
 - k. Initiate a DD Form 1380 (US Field Medical Card)
- 7. Evacuation of Sick and Wounded
 - a. Transport a patient on an improvised litter
 - b. Perform a four-hand seat carry
 - c. Perform a fireman's carry
 - d. Perform a pistol-belt carry
 - e. Load and unload a front line ambulance truck
 - f. Load and unload a 2 1/2 ton cargo truck
 - g. Load and unload a 1 1/4 ton ambulance truck
 - h. Load and unload a helicopter
- 8. Litter Obstacle Course
- 9. Cardiopulmonary Resuscitation

Appendix B

SIMULATION VARIABLES AND RESOURCES

<u>SLAM Global Variable</u>	<u>Variable Name</u>	<u>Purpose</u>
XX(1)	NUM_OF_GROUPS	Indicates the number of groups.
XX(2)	CANDIDATES_PER_GROUP	Indicates the number of candidates per group.
XX(3)	GATE_COUNTER	Maintains the number of day in the simulation.
XX(4)	DAILY_TNG_TIME	Indicates the number of hours planned for daily training.
XX(5)	DLN_COUNTER	Maintains the number of candidates per group processing through the DLN station. Used to facilitate logic in batch processes.
XX(6)	NLN_COUNTER	Same as XX(5) except for NLN.
XX(7)	LOC_COUNTER	Same as XX(5) except for LOC course.
XX(8)	GATE_TIME	Maintains the end of training time for each day.

<u>Candidate Attribute</u>	<u>Attribute Name</u>	<u>Purpose</u>
Atrib(1)	GROUP_NUM	Indicates candidate's group number. Used as a batching reference.
Atrib(2)	GROUP_SIZE	Indicates how many candidates in each group. Used as a batching threshold.
Atrib(3)	STATION_NUM	Indicates the position in the training schedule array.
Atrib(4)	TOT_TM_IN_SYS	Maintains the total time candidates are in the performance test.
Atrib(5)	Group batch reference	Set by SLAM to be an internal reference to the individual candidates in the batched groups.
Array (Atrib(1),	Atrib(3)) NEXT_STA	Maintains the schedule station identifier for the indicated group. Used to identify the current station for each candidate.
Atrib(6)	TOT_TM_DLN	Maintains the total time candidates are at the DLN. Used to calculate group time and average group time at the DLN station.
Atrib(7)	TOT_TM_NLN	Same as attribute 6 except for the NLN station.

<u>Candidate Attribute</u>	<u>Attribute Name</u>	<u>Purpose</u>
Atrib(8)	TOT_TM_ST	Same as attribute 6 except for the ST station.
Atrib(9)	TOT_TM_EMT	Same as attribute 6 except for the EMT station.
Atrib(10)	CPR	Indicates whether the candidate has processed through the cardiopulmonary resuscitation station (1 for processed; 0 for not).
Atrib(11)	EMT	Same as attribute 10 except applicable to the EMT station.
Atrib(12)	TOT_TM_LOC	Same as attribute 6 except for the LOC station.
Atrib(13)	none	Used to insure all candidates begin the road march at the same time.
Atrib(14)	TOT_TM_COM	Same as for attribute 6 except for the COM station.
Atrib(15)	MEDIVAC	Same as attribute 10 except applicable to the medivac task.
Atrib(16)	RADIO_NET	Same as attribute 10 except applicable to the enter a radio net and authenticate task.
Atrib(17)	OPERATE	Same as attribute 10 except applicable to the two tasks on operating radios.

<u>Candidate Attribute</u>	<u>Attribute Name</u>	<u>Purpose</u>
Atrib(18)	TOT_TM_ESW	Same as attribute 6 except for the ESW station.
Atrib(19)	ESWC	Indicates the number of ESW tasks that each candidate has completed. Used to indicate when the candidate has completed all tasks.
Atrib(20)	TOT_TM_RM	Maintains the time all candidates are at the road march station.
<u>Resource/ Capacity</u>	<u>Resource Name</u>	<u>Purpose</u>
1 / 1	DLN	Moves 10 candidates at a time in 15 minute intervals to the starting point of the DLN station.
2 / 1	NLN	Same as resource 1 except for the NLN.
3/user	ST_1	Moves candidates through the first three stations of the ST station. Capacity is input by the user.
4/user	ST_2	Models the number of concurrent ST stations or candidates that can be processed at the same time.
5/user	REMT	Models the number of EMT stations.

<u>Resource/ Capacity</u>	<u>Resource Name</u>	<u>Purpose</u>
6 / 1	LOC	Models the evaluation team assigned to the litter obstacle course.
Communications		
7 / 4	MEDI	Models the concurrent medivac task testing resources.
8 / 1	RADI	Models the evaluator package at the enter a radio net and authenticate task.
9 / 1	OPER	Models the evaluator package at the operate field telephone and radio task.
Evacuation of sick and wounded		
10 / 1	IMPROLIT	Models the evaluator package at the improvised litter task.
11 / 1	FOUR_H	Models the evaluator package at the four hand carry task.
12 / 1	FIRMAN	Models the evaluator package at the fireman's carry task.
13 / 1	PISTOL	Models the evaluator package at the pistol carry task.
14 / 1	FLA	Models the evaluator package at the front line ambulance task.
15 / user	DEUCE	Models the evaluator package at the two and one half ton truck station.

<u>Resource/ Capacity</u>	<u>Resource Name</u>	<u>Purpose</u>
16/user	QUARTER	Models the evaluator package at the one and one quarter ton truck station.
17/user	HELI	Models the evaluator package at the helicopter task.

Appendix C

USER'S MANUAL FOR THE EFMB SIMULATION PROGRAM

This Appendix describes the actions required by a user of the EFMB simulation program. The first section describes the hardware and software on which the program was developed. The following sections explain the actions required by the user to input the parameters of a projected EFMB test. Finally, the output reports are described.

C.1 Hardware and Software

The SLAM network code was developed under the SLAM II simulation language, version 4.03, on the University of Texas IBM 3081 mainframe computer. The FORTRAN subroutines were developed under VS FORTRAN, version 2.4, also on the mainframe computer. The IBM 3081 uses the VM/XA SP 2.1 operating system.

C.2 Actions Required by the User

The SLAM simulation language as set up at the University of Texas has established default values for the reader, the printer, the tape, and the terminal. These assignments are in the FORTRAN main program at the top of the FORTRAN user insert (See Appendix G). Before the EFMB simulation can be run, the user should verify these assignments or change them to meet the configuration of the local system.

The user types the following commands to begin the EFMB simulation program. SLAM, followed by the two filenames, <filename with extension data> and <filename with extension text>. The filename with extension data is the file containing the SLAM network program and the filename with extension text is the

compiled FORTRAN program.

After the above command has been issued, the computer prompts:

INPUT THE PARAMETERS FOR THE PROJECTED EFMB SIMULATION.

INPUT THE NUMBER OF GROUPS: =>

INPUT THE NUMBER OF CANDIDATES PER GROUP: =>

INPUT THE DAILY TRAINING DURATION IN HOURS: =>

These questions are answered with integers for the first two questions and a decimal equivalent for hours for the third question (i.e. nine and one half hours is 9.5). The computer then requests that the schedule for the first group be entered. The prompt appears as follows:

INPUT THE SCHEDULE FOR GROUP 1 USING THE CODES BELOW:

<u>SCHEDULE CODE</u>	<u>EVENT</u>
1	DAY LAND NAVIGATION
2	NIGHT LAND NAVIGATION
3	SURVIVAL TRAINING
4	EMERGENCY MEDICAL TREATEMNT AND CPR
5	LITTER OBSTACLE COURSE
6	COMMUNICATIONS
7	EVACUATION OF SICK AND WOUNDED
8	ROADMARCH
9	ALL STATIONS COMPLETE
10	END OF DAY ONE TRAINING
20	END OF DAY TWO TRAINING
30	END OF DAY THREE TRAINING
40	END OF DAY FOUR TRAINING
99	TERMINATE SCHEDULE INPUT ; EXIT TO SYSTEM

INPUT CODE FOR SCHEDULE POSITION 1: =>

The last statement above repeats itself for a maximum of 13 times indicating the possible 13 schedule positions in the longest schedule. The end of each day's training is input as a multiple of ten. For instance, 10 is the code for the end of the first day's training. When all codes have been entered, input the number 9 to indicate the schedule is complete. This process continues for each group. While the data is being entered, it is also being checked and written to a file for use in the later simulation runs. At the end of the simulation, the computer will return to the operating system and the output reports may then be examined.

During this schedule input process, only the above codes may be entered. If any other numbers or letters are input, an error message is displayed and the user is prompted to reenter the correct code. If a user wishes to terminate the input process the code 99 is entered as a schedule code. Below is the error message that results from an incorrect data entry for the first schedule position.

**LAST PARAMETER INPUT IS NOT A VALID CODE. PLEASE REENTER.
INPUT CODE FOR SCHEDULE POSITION 1: =>**

After the schedule has been entered, the user inputs the number of survival training station replications, the number of emergency medical treatment station replications, and the number of two and one half truck, the number of quarter ton truck, and the number of helicopter duplicate tasks in the evacuation of sick and wounded station. Integers are input for all questions. The prompts displayed on the computer screen appear below.

**INPUT THE NUMBER OF SURVIVAL TRAINING STATIONS: =>
INPUT THE NUMBER OF EMERGENCY MEDICAL TREATMENT
STATIONS: =>**

INPUT THE NUMBER OF TWO AND ONE HALF TON TRUCK
 DUPLICATE TASKS: =>
 INPUT THE NUMBER OF ONE AND ONE QUARTER TON TRUCK
 DUPLICATE TASKS: =>
 INPUT THE NUMBER OF HELICOPTER DUPLICATE TASKS: =>

This completes the data input process.

C.3 Description and Sample of Output Reports

The number of EFMB performance tests simulated is 30. The output is divided into three parts. The first consists of a warning message. It notifies the reader that if a schedule is not feasible and causes a group to work throughout the night and into the next day, the simulation will be terminated and the results up to the point of infeasibility will be printed. The second part consists of a parameter listing for the EFMB test applicable to the output and the SLAM summary report for the first simulation run. The third part consists of a detailed analysis of the late and slack times associated with the 30th simulation run, statistics on the average total late time, average total slack time, and the sum of these two, and a summary report for the last simulation run. The statistics labelled AVE, GROUP, and WAIT are statistics collected over the 30 simulation runs. Also, a message is printed if the average group completion time for the night land navigation station exceeds 6 hours (based on the 30 simulated EFMB performance tests). An example output report is listed on the following pages.

IF THE SCHEDULE IS NOT FEASIBLE AND CAUSES A GROUP TO WORK THROUGHOUT THE NIGHT AND INTO THE NEXT DAY, THE SIMULATION RESULTS UP TO THE POINT OF INFEASIBILITY WILL BE PRINTED.

RESULTS OF THE SIMULATION FOR THE FOLLOWING EFMB TEST PARAMETERS

NUMBER OF GROUPS 4.
 CANDIDATES PER GROUP 15.
 DAILY TRAINING DURATION 9.5
 NUMBER OF SURVIVAL LANE REPETITIONS 3
 NUMBER OF EMERGENCY MEDICAL TREATMENT LANE REPETITIONS 4

NUMBER OF TWO AND ONE HALF TON TRUCK TASKS 1
 NUMBER OF QUARTER TON TRUCK TASKS 2
 NUMBER OF HELICOPTER TASKS 1

SCHEDULE POSITIONS

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13.

GROUP 1 SCHEDULE IS:

7. 6. 3. 10. 5. 4. 1. 2. 20. 8. 9.

GROUP 2 SCHEDULE IS:

1. 7. 5. 10. 6. 3. 4. 2. 20. 8. 9.

GROUP 3 SCHEDULE IS:

5. 4. 7. 10. 3. 1. 6. 2. 20. 8. 9.

GROUP 4 SCHEDULE IS:

6. 3. 1. 10. 4. 7. 5. 2. 20. 8. 9.

SCHEDULE CODE EVENT

| | |
|----|-------------------------------------|
| 1 | DAY LAND NAVIGATION |
| 2 | NIGHT LAND NAVIGATION |
| 3 | SURVIVAL TRAINING |
| 4 | EMERGENCY MEDICAL TREATMENT AND CPR |
| 5 | LITTER OBSTACLE COURSE |
| 6 | COMMUNICATIONS |
| 7 | EVACUATION OF SICK AND WOUNDED |
| 8 | ROADMARCH |
| 9 | ALL STATIONS COMPLETE |
| 10 | END OF DAY ONE TRAINING |
| 20 | END OF DAY TWO TRAINING |
| 30 | END OF DAY THREE TRAINING |
| 40 | END OF DAY FOUR TRAINING |

SUMMARY REPORT FOR THE FIRST SIMULATION RUN

SLAM II SUMMARY REPORT

SIMULATION PROJECT EFMB

BY JSEES

DATE 4/ 2/1992

RUN NUMBER 1 OF 30

CURRENT TIME 0.1200E+03

STATISTICAL ARRAYS CLEARED AT TIME 0.0000E+00

STATISTICS FOR VARIABLES BASED ON OBSERVATION

| | MEAN
VALUE | STANDARD
DEVIATION | COEFF. OF
VARIATION | MINIMUM
VALUE | MAXIMUM
VALUE | NUMBER OF
OBS |
|----------------|---------------|-----------------------|------------------------|------------------|------------------|------------------|
| AVE EFMB TIME | 0.5103E+02 | 0.0000E+00 | 0.0000E+00 | 0.5103E+02 | 0.5103E+02 | 1 |
| AVE LATE TIME | 0.5887E+00 | 0.0000E+00 | 0.0000E+00 | 0.5887E+00 | 0.5887E+00 | 1 |
| AVE NUM LATE | 0.6000E+01 | 0.0000E+00 | 0.0000E+00 | 0.6000E+01 | 0.6000E+01 | 1 |
| AVE SLACK TIME | 0.5954E+00 | 0.0000E+00 | 0.0000E+00 | 0.5954E+00 | 0.5954E+00 | 1 |
| AVE NUM SLACK | 0.2000E+01 | 0.0000E+00 | 0.0000E+00 | 0.2000E+01 | 0.2000E+01 | 1 |
| CROUP DLN__ 1 | 0.4211E+01 | 0.0000E+00 | 0.0000E+00 | 0.4211E+01 | 0.4211E+01 | 1 |
| GROUP NLN__ 2 | 0.4668E+01 | 0.0000E+00 | 0.0000E+00 | 0.4668E+01 | 0.4668E+01 | 1 |
| GROUP ST__ 3 | 0.4488E+01 | 0.0000E+00 | 0.0000E+00 | 0.4488E+01 | 0.4488E+01 | 1 |
| GROUP EMT__ 4 | 0.3273E+01 | 0.0000E+00 | 0.0000E+00 | 0.3273E+01 | 0.3273E+01 | 1 |
| GROUP LOC__ 5 | 0.2829E+01 | 0.0000E+00 | 0.0000E+00 | 0.2829E+01 | 0.2829E+01 | 1 |
| GROUP COM__ 6 | 0.1708E+01 | 0.0000E+00 | 0.0000E+00 | 0.1708E+01 | 0.1708E+01 | 1 |
| GROUP ESW__ 7 | 0.2987E+01 | 0.0000E+00 | 0.0000E+00 | 0.2987E+01 | 0.2987E+01 | 1 |
| GROUP RM__ 8 | 0.2962E+01 | 0.0000E+00 | 0.0000E+00 | 0.2962E+01 | 0.2962E+01 | 1 |
| WAIT DLN | 0.1250E+00 | 0.0000E+00 | 0.0000E+00 | 0.1250E+00 | 0.1250E+00 | 1 |
| WAIT NLN | 0.3967E+00 | 0.0000E+00 | 0.0000E+00 | 0.3967E+00 | 0.3967E+00 | 1 |
| WAIT ST1 | 0.1307E+01 | 0.0000E+00 | 0.0000E+00 | 0.1307E+01 | 0.1307E+01 | 1 |

STATISTICS FOR VARIABLES BASED ON OBSERVATION

| | MEAN
VALUE | STANDARD
DEVIATION | COEFF. OF
VARIATION | MINIMUM
VALUE | MAXIMUM
VALUE | NUMBER OF
OBS |
|-----------------|---------------|-----------------------|------------------------|------------------|------------------|------------------|
| WAIT ST2 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 1 |
| WAIT EMT | 0.5340E+00 | 0.0000E+00 | 0.0000E+00 | 0.5340E+00 | 0.5340E+00 | 1 |
| WAIT LOC | 0.8334E+00 | 0.0000E+00 | 0.0000E+00 | 0.8334E+00 | 0.8334E+00 | 1 |
| WAIT CM | 0.1495E-01 | 0.0000E+00 | 0.0000E+00 | 0.1495E-01 | 0.1495E-01 | 1 |
| WAIT CR | 0.2695E+00 | 0.0000E+00 | 0.0000E+00 | 0.2695E+00 | 0.2695E+00 | 1 |
| WAIT CO | 0.5378E+00 | 0.0000E+00 | 0.0000E+00 | 0.5378E+00 | 0.5378E+00 | 1 |
| WAIT IMPR | 0.1621E+00 | 0.0000E+00 | 0.0000E+00 | 0.1621E+00 | 0.1621E+00 | 1 |
| WAIT FOUR | 0.1000E-02 | 0.0000E+00 | 0.0000E+00 | 0.1000E-02 | 0.1000E-02 | 1 |
| WAIT FIRM | 0.3904E-02 | 0.0000E+00 | 0.0000E+00 | 0.3904E-02 | 0.3904E-02 | 1 |
| WAIT PIST | 0.4951E-02 | 0.0000E+00 | 0.0000E+00 | 0.4951E-02 | 0.4951E-02 | 1 |
| WAIT FLA | 0.1134E-01 | 0.0000E+00 | 0.0000E+00 | 0.1134E-01 | 0.1134E-01 | 1 |
| WAIT DEUC | 0.8962E+00 | 0.0000E+00 | 0.0000E+00 | 0.8962E+01 | 0.8962E+00 | 1 |
| WAIT QUAR | 0.1858E-01 | 0.0000E+00 | 0.0000E+00 | 0.1858E-01 | 0.1858E-01 | 1 |
| WAIT HELI | 0.2423E+00 | 0.0000E+00 | 0.0000E+00 | 0.2423E+00 | 0.2423E+00 | 1 |
| SLACK TIME | 0.5954E+00 | 0.1073E+00 | 0.1802E+00 | 0.5195E+00 | 0.6712E+00 | 2 |
| LATE TIME | 0.5887E+00 | 0.4089E+00 | 0.6946E+00 | 0.1417E+00 | 0.1089E+01 | 6 |
| END 1ST DAY TNG | 0.9477E+01 | 0.0000E+00 | 0.0000E+00 | 0.9477E+01 | 0.9477E+01 | 1 |
| END 2ND DAY TNG | 0.3348E+02 | 0.0000E+00 | 0.0000E+00 | 0.3348E+02 | 0.3348E+02 | 1 |
| END 3RD DAY TNG | 0.5748E+02 | 0.0000E+00 | 0.0000E+00 | 0.5748E+02 | 0.5748E+02 | 1 |
| END 4TH DAY TNG | 0.8148E+02 | 0.0000E+00 | 0.0000E+00 | 0.8148E+02 | 0.8148E+02 | 1 |
| END 5TH DAY TNG | 0.1055E+03 | 0.0000E+00 | 0.0000E+00 | 0.1055E+03 | 0.1055E+03 | 1 |
| DLN GP1 FIN__1 | 0.3314E+02 | 0.4594E+00 | 0.1386E-01 | 0.3247E+02 | 0.3407E+02 | 15 |
| DLN GP2 FIN__1 | 0.2882E+01 | 0.3009E+00 | 0.1044E+00 | 0.2379E+01 | 0.3386E+01 | 15 |
| DLN GP3 FIN__1 | 0.3130E+02 | 0.5548E+00 | 0.1772E-01 | 0.3009E+02 | 0.3216E+02 | 15 |
| DLN GP4 FIN__1 | 0.8373E+01 | 0.4740E+00 | 0.5661E-01 | 0.7407E+01 | 0.9318E+01 | 15 |
| AVG GRPTM DLN | 0.4211E+01 | 0.2202E+00 | 0.5230E-01 | 0.3886E+01 | 0.4350E+01 | 4 |
| NLN GP1 FIN__2 | 0.3827E+02 | 0.4651E+00 | 0.1215E-01 | 0.3767E+02 | 0.3916E+02 | 5 |
| NLN GP2 FIN__2 | 0.3784E+02 | 0.4680E+00 | 0.1237E-01 | 0.3711E+02 | 0.3888E+02 | 5 |
| NLN GP3 FIN__2 | 0.3736E+02 | 0.5922E+00 | 0.1585E-01 | 0.3637E+02 | 0.3832E+02 | 15 |
| NLN GP4 FIN__2 | 0.3658E+02 | 0.5993E+00 | 0.1638E-01 | 0.3501E+02 | 0.3750E+02 | 15 |

| | | | | | | |
|---------------|------------|------------|------------|------------|------------|----|
| AVG GRPTM NLN | 0.4668E+01 | 0.3022E+00 | 0.6473E-01 | 0.4392E+01 | 0.4994E+01 | 4 |
| ST GP1 FIN_3 | 0.7515E+01 | 0.9442E+00 | 0.1256E+00 | 0.6129E+01 | 0.8980E+01 | 15 |
| ST GP2 FIN_3 | 0.2989E+02 | 0.9123E+00 | 0.3052E-01 | 0.2838E+02 | 0.3121E+02 | 15 |
| ST GP3 FIN_3 | 0.2674E+02 | 0.9909E+00 | 0.3706E-01 | 0.2553E+02 | 0.2831E+02 | 5 |
| ST GP4 FIN_3 | 0.4267E+01 | 0.8948E+00 | 0.2097E+00 | 0.3152E+01 | 0.5553E+01 | 15 |
| AVG GRPTM ST | 0.4488E+01 | 0.7548E+00 | 0.1682E+00 | 0.3734E+01 | 0.5523E+01 | 4 |
| EMT GP1 FIN_4 | 0.2870E+02 | 0.8274E+00 | 0.2883E-01 | 0.2755E+02 | 0.3022E+02 | 15 |
| EMT GP2 FIN_4 | 0.3304E+02 | 0.8318E+00 | 0.2518E-01 | 0.3175E+02 | 0.3442E+02 | 15 |
| EMT GP3 FIN_4 | 0.4789E+01 | 0.8520E+00 | 0.1779E+00 | 0.3690E+01 | 0.6293E+01 | 15 |
| EMT GP4 FIN_4 | 0.2587E+02 | 0.8307E+00 | 0.3212E-01 | 0.2480E+02 | 0.2714E+02 | 15 |
| AVG GRPTM EMT | 0.3273E+01 | 0.1275E+00 | 0.3895E-01 | 0.3126E+01 | 0.3385E+01 | 4 |
| LOC GP1 FIN_5 | 0.2567E+02 | 0.5938E+00 | 0.2313E-01 | 0.2493E+02 | 0.2651E+02 | 15 |
| LOC GP2 FIN_5 | 0.8388E+01 | 0.6306E+00 | 0.7517E-01 | 0.7596E+01 | 0.9289E+01 | 15 |
| LOC GP3 FIN_5 | 0.1737E+01 | 0.6222E+00 | 0.3582E+00 | 0.9220E+00 | 0.2588E+01 | 15 |
| LOC GP4 FIN_5 | 0.3168E+02 | 0.5789E+00 | 0.1827E-01 | 0.3094E+02 | 0.3248E+02 | 15 |
| AVG GRPTM LOC | 0.2829E+01 | 0.9300E-01 | 0.3288E-01 | 0.2739E+01 | 0.2918E+01 | 4 |
| COM GP1 FIN_6 | 0.3977E+01 | 0.3506E+00 | 0.8814E-01 | 0.3346E+01 | 0.4508E+01 | 15 |
| COM GP2 FIN_6 | 0.2524E+02 | 0.2679E+00 | 0.1061E-01 | 0.2479E+02 | 0.2569E+02 | 15 |
| COM GP3 FIN_6 | 0.3380E+02 | 0.3488E+00 | 0.1032E-01 | 0.3319E+02 | 0.3429E+02 | 15 |
| COM GP4 FIN_6 | 0.1078E+01 | 0.5164E+00 | 0.4788E+00 | 0.2114E+00 | 0.1819E+01 | 15 |
| AVG GRPTM COM | 0.1708E+01 | 0.8000E-01 | 0.4684E-01 | 0.1632E+01 | 0.1819E+01 | 4 |

STATISTICS FOR VARIABLES BASED ON OBSERVATION

| | MEAN
VALUE | STANDARD
DEVIATION | COEFF. OF
VARIATION | MINIMUM
VALUE | MAXIMUM
VALUE | NUMBER OF
OBS |
|---------------|---------------|-----------------------|------------------------|------------------|------------------|------------------|
| ESW GP1 FIN_7 | 0.2031E+01 | 0.5799E+00 | 0.2855E+00 | 0.1170E+01 | 0.2802E+01 | 15 |
| ESW GP2 FIN_7 | 0.6024E+01 | 0.3977E+00 | 0.6603E-01 | 0.5443E+01 | 0.6720E+01 | 15 |
| ESW GP3 FIN_7 | 0.8739E+01 | 0.7050E+00 | 0.8067E-01 | 0.7542E+01 | 0.9682E+01 | 15 |
| ESW GP4 FIN_7 | 0.2930E+02 | 0.3763E+00 | 0.1284E-01 | 0.2871E+02 | 0.3007E+02 | 15 |
| AVG GRPTM ESW | 0.2987E+01 | 0.2724E+00 | 0.9120E-01 | 0.2802E+01 | 0.3389E+01 | 4 |
| AVG GRPTM RM | 0.2962E+01 | 0.8670E-01 | 0.2927E-01 | 0.2856E+01 | 0.3060E+01 | 4 |
| TOT TM IN SYS | 0.5103E+02 | 0.6036E-01 | 0.1183E-02 | 0.5095E+02 | 0.5112E+02 | 60 |

FILE STATISTICS

| FILE
NUMBER | LABEL/TYPE | AVERAGE
LENGTH | STANDARD
DEVIATION | MAXIMUM
LENGTH | CURRENT
LENGTH | AVERAGE
WAITING TIME |
|----------------|-------------|-------------------|-----------------------|-------------------|-------------------|-------------------------|
| 1 | RDLN AWAIT | 0.0083 | 0.0909 | 1 | 0 | 0.1250 |
| 2 | RNLN AWAIT | 0.0264 | 0.2662 | 4 | 0 | 0.3967 |
| 3 | RST1 AWAIT | 0.6534 | 2.4868 | 19 | 0 | 1.3068 |
| 4 | RST2 AWAIT | 0.0000 | 0.0000 | 1 | 0 | 0.0000 |
| 5 | REMR AWAIT0 | 0.2670 | 0.9427 | 4 | 0 | 0.5340 |
| 6 | RLOC AWAIT | 0.1111 | 0.4971 | 3 | 0 | 0.8334 |
| 7 | CM AWAIT | 0.0075 | 0.1219 | 4 | 0 | 0.0149 |
| 8 | CR AWAIT | 0.1348 | 0.6745 | 6 | 0 | 0.2695 |
| 9 | CO AWAIT | 0.2689 | 1.3575 | 13 | 0 | 0.5378 |
| 10 | IMPR AWAIT | 0.0810 | 0.5372 | 7 | 0 | 0.1621 |
| 11 | FOUR AWAIT | 0.0005 | 0.0224 | 1 | 0 | 0.0010 |
| 12 | FIRM AWAIT | 0.0020 | 0.0543 | 2 | 0 | 0.0039 |
| 13 | PIST AWAIT | 0.0025 | 0.0497 | 1 | 0 | 0.0050 |
| 14 | FLA AWAIT | 0.0057 | 0.0888 | 2 | 0 | 0.0113 |
| 15 | DEUC AWAIT | 0.4481 | 1.6176 | 12 | 0 | 0.8962 |

| | | | | | | |
|----|------------|--------|---------|----|---|--------|
| 16 | QUAR AWAIT | 0.0093 | 0.1374 | 3 | 0 | 0.0186 |
| 17 | HELI AWAIT | 0.1211 | 0.6378 | 5 | 0 | 0.2423 |
| 18 | GN AWAIT | 0.0000 | 0.0000 | 0 | 0 | 0.0000 |
| 19 | | 0.0000 | 0.0000 | 0 | 0 | 0.0000 |
| 20 | | 0.0000 | 0.0000 | 0 | 0 | 0.0000 |
| 21 | CALENDAR | 8.3200 | 13.5814 | 61 | 0 | 0.1036 |

RESOURCE STATISTICS

| RESOURCE
NUMBER | RESOURCE
LABEL | CURRENT
CAPACITY | AVERAGE
UTILIZATION | STANDARD
DEVIATION | MAXIMUM
UTILIZATION | CURRENT
UTILIZATION |
|--------------------|-------------------|---------------------|------------------------|-----------------------|------------------------|------------------------|
| 1 | DLN | 1 | 0.0167 | 0.1280 | 1 | 0 |
| 2 | NLN | 1 | 0.0167 | 0.1280 | 1 | 0 |
| 3 | ST_1 | 3 | 0.2838 | 0.8759 | 3 | 0 |
| 4 | ST_2 | 6 | 0.5946 | 1.7167 | 6 | 0 |
| 5 | REMT | 4 | 0.3791 | 1.1398 | 4 | 0 |
| 6 | LOC | 1 | 0.0723 | 0.2590 | 1 | 0 |
| 7 | MEDI | 4 | 0.0612 | 0.4379 | 4 | 0 |

RESOURCE STATISTICS

| RESOURCE
NUMBER | RESOURCE
LABEL | CURRENT
CAPACITY | AVERAGE
UTILIZATION | STANDARD
DEVIATION | MAXIMUM
UTILIZATION | CURRENT
UTILIZATION |
|--------------------|-------------------|---------------------|------------------------|-----------------------|------------------------|------------------------|
| 8 | RADI | 1 | 0.0557 | 0.2294 | 1 | 0 |
| 9 | OPER | 1 | 0.0500 | 0.2179 | 1 | 0 |
| 10 | IMPROLIT | 1 | 0.0450 | 0.2073 | 1 | 0 |
| 11 | FOUR_H | 1 | 0.0100 | 0.0995 | 1 | 0 |
| 12 | FIRMAN | 1 | 0.0150 | 0.1216 | 1 | 0 |
| 13 | PISTOL | 1 | 0.0485 | .2148 | 1 | 0 |
| 14 | FLA | 1 | 0.0601 | 0.2377 | 1 | 0 |
| 15 | DEUCE | 1 | 0.0951 | 0.2934 | 1 | 0 |
| 16 | QUARTER | 2 | 0.0774 | 0.3077 | 2 | 0 |
| 17 | HELI | 1 | 0.0756 | 0.2644 | 1 | 0 |

| RESOURCE
NUMBER | RESOURCE
LABEL | CURRENT
AVAILABLE | AVERAGE
AVAILABLE | MINIMUM
AVAILABLE | MAXIMUM
AVAILABLE |
|--------------------|-------------------|----------------------|----------------------|----------------------|----------------------|
| 1 | DLN | 1 | 0.9833 | 0 | 1 |
| 2 | NLN | 1 | 0.9833 | 0 | 1 |
| 3 | ST_1 | 3 | 2.7162 | 0 | 3 |
| 4 | ST_2 | 6 | 5.4054 | 0 | 6 |
| 5 | REMT | 4 | 3.6209 | 0 | 4 |
| 6 | LOC | 1 | 0.9277 | 0 | 1 |
| 7 | MEDI | 4 | 3.9388 | 0 | 4 |
| 8 | RADI | 1 | 0.9443 | 0 | 1 |
| 9 | OPER | 1 | 0.9500 | 0 | 1 |
| 10 | IMPROLIT | 1 | 0.9550 | 0 | 1 |
| 11 | FOUR_H | 1 | 0.9900 | 0 | 1 |
| 12 | FIRMAN | 1 | 0.9850 | 0 | 1 |
| 13 | PISTOL | 1 | 0.9515 | 0 | 1 |
| 14 | FLA | 1 | 0.9399 | 0 | 1 |

| | | | | | |
|----|---------|---|--------|---|---|
| 15 | DEUCE | 1 | 0.9049 | 0 | 1 |
| 16 | QUARTER | 2 | 1.9226 | 0 | 2 |
| 17 | HELI | 1 | 0.9244 | 0 | 1 |

****GATE STATISTICS****

| GATE
NUMBER | GATE
LABEL | CURRENT
STATUS | PCT. OF
TIME OPEN |
|----------------|---------------|-------------------|----------------------|
| 1 | GNET | OPEN | 0.3958 |

RESULTS OF THE SIMULATION FOR THE FOLLOWING EFMB TEST PARAMETERS

NUMBER OF GROUPS 4.
 CANDIDATES PER GROUP 15.
 DAILY TRAINING DURATION 9.5
 NUMBER OF SURVIVAL LANE REPETITIONS 3
 NUMBER OF EMERGENCY MEDICAL TREATMENT LANE REPETITIONS 4
 NUMBER OF TWO AND ONE HALF TON TRUCK TASKS 1
 NUMBER OF QUARTER TON TRUCK TASKS 2
 NUMBER OF HELICOPTER TASKS 1

SCHEDULE POSITIONS

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13.

GROUP 1 SCHEDULE IS:

7. 6. 3. 10. 5. 4. 1. 2. 20. 8. 9.

GROUP 2 SCHEDULE IS:

1. 7. 5. 10. 6. 3. 4. 2. 20. 8. 9.

GROUP 3 SCHEDULE IS:

5. 4. 7. 10. 3. 1. 6. 2. 20. 8. 9.

GROUP 4 SCHEDULE IS:

6. 3. 1. 10. 4. 7. 5. 2. 20. 8. 9.

SCHEDULE CODE EVENT

| | |
|---|-------------------------------------|
| 1 | DAY LAND NAVIGATION |
| 2 | NIGHT LAND NAVIGATION |
| 3 | SURVIVAL TRAINING |
| 4 | EMERGENCY MEDICAL TREATMENT AND CPR |

5 LITTER OBSTACLE COURSE
 6 COMMUNICATIONS
 7 EVACUATION OF SICK AND WOUNDED
 8 ROADMARCH
 9 ALL STATIONS COMPLETE
 10 END OF DAY ONE TRAINING
 20 END OF DAY TWO TRAINING
 30 END OF DAY THREE TRAINING
 40 END OF DAY FOUR TRAINING

SPECIFIC LATE AND SLACK TIME INFORMATION FOR SIMULATION RUN 30

GROUP: 1. SCHEDULE POSITION: 3. SLACK TIME: 0.979618073
 GROUP: 4. SCHEDULE POSITION: 3. SLACK TIME: 0.108498573
 GROUP: 3. SCHEDULE POSITION: 3. LATE TIME: 0.213683128
 GROUP: 2. SCHEDULE POSITION: 3. LATE TIME: 0.850449562
 GROUP: 4. SCHEDULE POSITION: 7. SLACK TIME: 0.589004517
 GROUP: 3. SCHEDULE POSITION: 7. LATE TIME: 0.273910522
 GROUP: 2. SCHEDULE POSITION: 7. LATE TIME: 0.582550049
 GROUP: 1. SCHEDULE POSITION: 7. LATE TIME: 1.360900880

60389904.0

MICROSECONDS OF CPU TIME WERE USED

AVERAGE TOTAL LATE TIME IS:3.524947170
 AVERAGE TOTAL SLACK TIME IS:1.467705730
 AVERAGE TOTAL TIME LATE PLUS AVERAGE TOTAL SLACK TIME:4.992652890

SUMMARY REPORT FOR THE LAST SIMULATION RUN

SLAM II SUMMARY REPORT

SIMULATION PROJECT EFMB
 DATE 4/2/1992

BY JSEES
 RUN NUMBER 30 OF 30

CURRENT TIME 0.1200E+03
 STATISTICAL ARRAYS CLEARED AT TIME 0.0000E+00

STATISTICS FOR VARIABLES BASED ON OBSERVATION

| | MEAN
VALUE | STANDARD
DEVIATION | COEFF. OF
VARIATION | MINIMUM
VALUE | MAXIMUM
VALUE | NUMBER OF
OBS |
|----------------|---------------|-----------------------|------------------------|------------------|------------------|------------------|
| AVE EFMB TIME | 0.5111E+02 | 0.5583E-01 | 0.1092E-02 | 0.5103E+02 | 0.5125E+02 | 30 |
| AVE LATE TIME | 0.6184E+00 | 0.1239E+00 | 0.2003E+00 | 0.3974E+00 | 0.1025E+01 | 30 |
| AVE NUM LATE | 0.5700E+01 | 0.5350E+00 | 0.9386E-01 | 0.4000E+01 | 0.6000E+01 | 30 |
| AVE SLACK TIME | 0.6381E+00 | 0.1606E+00 | 0.2516E+00 | 0.2940E+00 | 0.9304E+00 | 30 |
| AVE NUM SLACK | 0.2300E+01 | 0.5350E+00 | 0.2326E+00 | 0.2000E+01 | 0.4000E+01 | 30 |
| GROUP DLN__ 1 | 0.4158E+01 | 0.1033E+00 | 0.2485E-01 | 0.3987E+01 | 0.4470E+01 | 30 |
| GROUP NLN__ 2 | 0.4831E+01 | 0.1640E+00 | 0.3395E-01 | 0.4571E+01 | 0.5145E+01 | 30 |

| | | | | | | | |
|-------------|---|------------|------------|------------|------------|------------|----|
| GROUP ST__ | 3 | 0.4378E+01 | 0.9470E-01 | 0.2163E-01 | 0.4153E+01 | 0.4546E+01 | 30 |
| GROUP EMT_ | 4 | 0.3195E+01 | 0.7591E-01 | 0.2376E-01 | 0.3056E+01 | 0.3377E+01 | 30 |
| GROUP LOC__ | 5 | 0.2776E+01 | 0.5011E-01 | 0.1805E-01 | 0.2665E+01 | 0.2882E+01 | 30 |
| GROUP COM_ | 6 | 0.1663E+01 | 0.2601E-01 | 0.1564E-01 | 0.1602E+01 | 0.1708E+01 | 30 |
| GROUP ESW_ | 7 | 0.3220E+01 | 0.1386E+00 | 0.4304E-01 | 0.2987E+01 | 0.3614E+01 | 30 |
| GROUP RM__ | 8 | 0.3065E+01 | 0.5746E-01 | 0.1875E-01 | 0.2962E+01 | 0.3197E+01 | 30 |
| WAIT DLN | | 0.1250E+00 | 0.9870E-07 | 0.7896E-06 | 0.1250E+00 | 0.1250E+00 | 30 |
| WAIT NLN | | 0.4225E+00 | 0.8529E-01 | 0.2019E+00 | 0.2830E+00 | 0.6067E+00 | 30 |
| WAIT ST1 | | 0.1195E+01 | 0.5051E-01 | 0.4225E-01 | 0.1101E+01 | 0.1315E+01 | 30 |
| WAIT ST2 | | 0.3434E-01 | 0.1887E-01 | 0.5493E+00 | 0.9556E-02 | 0.7439E-01 | 30 |
| WAIT EMT | | 0.5528E+00 | 0.1352E-01 | 0.2445E-01 | 0.5293E+00 | 0.5767E+00 | 30 |
| WAIT LOC | | 0.7934E+00 | 0.2764E-01 | 0.3484E-01 | 0.7512E+00 | 0.8430E+00 | 30 |
| WAIT CM | | 0.1179E-01 | 0.9760E-02 | 0.8280E+00 | 0.4864E-03 | 0.3957E-01 | 30 |
| WAIT CR | | 0.3399E+00 | 0.7028E-01 | 0.2068E+00 | 0.2309E+00 | 0.4937E+00 | 30 |
| WAIT CO | | 0.4955E+00 | 0.5091E-01 | 0.1027E+00 | 0.3767E+00 | 0.5730E+00 | 30 |
| WAIT IMPR | | 0.1901E+00 | 0.3755E-01 | 0.1975E+00 | 0.1162E+00 | 0.2489E+00 | 30 |
| WAIT FOUR | | 0.3473E-02 | 0.2693E-02 | 0.7754E+00 | 0.0000E+00 | 0.1150E-01 | 30 |
| WAIT FIRM | | 0.3176E-02 | 0.1988E-02 | 0.6262E+00 | 0.0000E+00 | 0.7299E-02 | 30 |
| WAIT PIST | | 0.2916E-01 | 0.2758E-01 | 0.9457E+00 | 0.7005E-03 | 0.1270E+00 | 30 |
| WAIT FLA | | 0.2710E-01 | 0.2250E-01 | 0.8301E+00 | 0.1358E-02 | 0.8888E-01 | 30 |
| WAIT DEUC | | 0.1014E+01 | 0.9022E-01 | 0.8898E-01 | 0.8260E+00 | 0.1205E+01 | 30 |

STATISTICS FOR VARIABLES BASED ON OBSERVATION

| | MEAN
VALUE | STANDARD
DEVIATION | COEFF. OF
VARIATION | MINIMUM
VALUE | MAXIMUM
VALUE | NUMBER OF
OBS |
|-----------------|---------------|-----------------------|------------------------|------------------|------------------|------------------|
| WAIT QUAR | 0.1013E-01 | 0.8134E-02 | 0.8032E+00 | 0.5362E-03 | 0.2985E-01 | 30 |
| WAIT HELI | 0.1994E+00 | 0.5697E-01 | 0.2857E+00 | 0.8732E-01 | 0.3416E+00 | 30 |
| SLACK TIME | 0.5590E+00 | 0.4363E+00 | 0.7805E+00 | 0.1085E+00 | 0.9796E+00 | 3 |
| LATE TIME | 0.6563E+00 | 0.4695E+00 | 0.7154E+00 | 0.2137E+00 | 0.1361E+01 | 5 |
| END 1ST DAY TNG | 0.9490E+01 | 0.0000E+00 | 0.0000E+00 | 0.9490E+01 | 0.9490E+01 | 1 |
| END 2ND DAY TNG | 0.3349E+02 | 0.0000E+00 | 0.0000E+00 | 0.3349E+02 | 0.3349E+02 | 1 |
| END 3RD DAY TNG | 0.5749E+02 | 0.0000E+00 | 0.0000E+00 | 0.5749E+02 | 0.5749E+02 | 1 |
| END 4TH DAY TNG | 0.8149E+02 | 0.0000E+00 | 0.0000E+00 | 0.8149E+02 | 0.8149E+02 | 1 |
| END 5TH DAY TNG | 0.1055E+03 | 0.0000E+00 | 0.0000E+00 | 0.1055E+03 | 0.1055E+03 | 1 |
| DLN GP1 FIN__1 | 0.3328E+02 | 0.4559E+00 | 0.1370E-01 | 0.3249E+02 | 0.3435E+02 | 15 |
| DLN GP2 FIN__1 | 0.2779E+01 | 0.4239E+00 | 0.1525E+00 | 0.2273E+01 | 0.3525E+01 | 15 |
| DLN GP3 FIN__1 | 0.3105E+02 | 0.3907E+00 | 0.1258E-01 | 0.3050E+02 | 0.3162E+02 | 15 |
| DLN GP4 FIN__1 | 0.8358E+01 | 0.3754E+00 | 0.4491E-01 | 0.7743E+01 | 0.8892E+01 | 15 |
| AVG GRP TM DLN | 0.4132E+01 | 0.2644E+00 | 0.6398E-01 | 0.3932E+01 | 0.4521E+01 | 4 |
| NLN GP1 FIN__2 | 0.3805E+02 | 0.6783E+00 | 0.1782E-01 | 0.3680E+02 | 0.3943E+02 | 15 |
| NLN GP2 FIN__2 | 0.3739E+02 | 0.5070E+00 | 0.1356E-01 | 0.3653E+02 | 0.3836E+02 | 1 |
| NLN GP3 FIN__2 | 0.3693E+02 | 0.7571E+00 | 0.2050E-01 | 0.3567E+02 | 0.3813E+02 | 15 |
| NLN GP4 FIN__2 | 0.3661E+02 | 0.5931E+00 | 0.1620E-01 | 0.3531E+02 | 0.3747E+02 | 15 |
| AVG GRP TM NLN | 0.4701E+01 | 0.2540E+00 | 0.5403E-01 | 0.4370E+01 | 0.4983E+01 | 4 |
| ST GP1 FIN__3 | 0.7214E+01 | 0.8669E+00 | 0.1202E+00 | 0.6007E+01 | 0.8520E+01 | 5 |
| ST GP2 FIN__3 | 0.2977E+02 | 0.9470E+00 | 0.3181E-01 | 0.2816E+02 | 0.3094E+02 | 15 |
| ST GP3 FIN__3 | 0.2660E+02 | 0.9512E+00 | 0.3576E-01 | 0.2540E+02 | 0.2807E+02 | 15 |
| ST GP4 FIN__3 | 0.4048E+01 | 0.8693E+00 | 0.2147E+00 | 0.2863E+01 | 0.5460E+01 | 15 |
| AVG GRP TM ST | 0.4268E+01 | 0.6417E+00 | 0.1504E+00 | 0.3871E+01 | 0.5222E+01 | 4 |
| EMT GP1 FIN__4 | 0.2898E+02 | 0.8507E+00 | 0.2936E-01 | 0.2779E+02 | 0.3033E+02 | 15 |
| EMT GP2 FIN__4 | 0.3282E+02 | 0.8187E+00 | 0.2494E-01 | 0.3169E+02 | 0.3407E+02 | 15 |
| EMT GP3 FIN__4 | 0.4664E+01 | 0.8492E+00 | 0.1821E+00 | 0.3540E+01 | 0.6028E+01 | 15 |
| EMT GP4 FIN__4 | 0.2587E+02 | 0.8242E+00 | 0.3186E-01 | 0.2477E+02 | 0.2721E+02 | 15 |
| AVG GRP TM EMT | 0.3175E+01 | 0.8464E-01 | 0.2666E-01 | 0.3115E+01 | 0.3300E+01 | 4 |
| LOC GP1 FIN__5 | 0.2578E+02 | 0.6565E+00 | 0.2547E-01 | 0.2496E+02 | 0.2670E+02 | 15 |

| | | | | | | |
|---------------|------------|------------|------------|------------|------------|----|
| LOC GP2 FIN_5 | 0.9290E+01 | 0.5542E+00 | 0.5966E-01 | 0.8603E+01 | 0.1001E+02 | 15 |
| LOC GP3 FIN_5 | 0.1636E+01 | 0.6523E+00 | 0.3987E+00 | 0.8162E+00 | 0.2545E+01 | 15 |
| LOC GP4 FIN_5 | 0.3173E+02 | 0.6277E+00 | 0.1978E-01 | 0.3089E+02 | 0.3257E+02 | 15 |
| AVG GRPTM LOC | 0.2834E+01 | 0.1689E+00 | 0.5959E-01 | 0.2605E+01 | 0.3010E+01 | 4 |
| COM GP1 FIN_6 | 0.4155E+01 | 0.2618E+00 | 0.6301E-01 | 0.3698E+01 | 0.4609E+01 | 15 |
| COM GP2 FIN_6 | 0.2528E+02 | 0.2589E+00 | 0.1024E-01 | 0.2482E+02 | 0.2572E+02 | 15 |
| COM GP3 FIN_6 | 0.3333E+02 | 0.2653E+00 | 0.7958E-02 | 0.3288E+02 | 0.3376E+02 | 15 |
| COM GP4 FIN_6 | 0.1188E+01 | 0.2760E+00 | 0.2323E+00 | 0.6648E+00 | 0.1588E+01 | 15 |
| AVG GRPTM COM | 0.1650E+01 | 0.4547E-01 | 0.2755E-01 | 0.1588E+01 | 0.1689E+01 | 4 |
| ESW GP1 FIN_7 | 0.2057E+01 | 0.5356E+00 | 0.2604E+00 | 0.1260E+01 | 0.2920E+01 | 15 |
| ESW GP2 FIN_7 | 0.6204E+01 | 0.8762E+00 | 0.1412E+00 | 0.5105E+01 | 0.7736E+01 | 15 |
| ESW GP3 FIN_7 | 0.8856E+01 | 0.4474E+00 | 0.5053E-01 | 0.8126E+01 | 0.9704E+01 | 15 |
| ESW GP4 FIN_7 | 0.2922E+02 | 0.5628E+00 | 0.1926E-01 | 0.2838E+02 | 0.3005E+02 | 15 |
| AVG GRPTM ESW | 0.3289E+01 | 0.4684E+00 | 0.1424E+00 | 0.2848E+01 | 0.3711E+01 | 4 |
| AVG GRPTM RM | 0.3139E+01 | 0.5210E-01 | 0.1660E-01 | 0.3081E+01 | 0.3194E+01 | 4 |
| TOT TM IN SYS | 0.5119E+02 | 0.3133E-01 | 0.6121E-03 | 0.5114E+02 | 0.5122E+02 | 60 |

FILE STATISTICS

| FILE
NUMBER | LABEL/TYPE | AVERAGE
LENGTH | STANDARD
DEVIATION | MAXIMUM
LENGTH | CURRENT
LENGTH | AVERAGE
WAITING TIME |
|----------------|------------|-------------------|-----------------------|-------------------|-------------------|-------------------------|
| 1 | RDLN AWAIT | 0.0083 | 0.0909 | 1 | 0 | 0.1250 |
| 2 | RNLN AWAIT | 0.0219 | 0.2024 | 3 | 0 | 0.3288 |
| 3 | RST1 AWAIT | 0.5933 | 2.3137 | 18 | 0 | 1.1867 |
| 4 | RST2 AWAIT | 0.0125 | 0.1411 | 2 | 0 | 0.0251 |
| 5 | REMR AWAI | 0.2726 | 0.9595 | 4 | 0 | 0.5451 |
| 6 | RLOC AWAIT | 0.1113 | 0.4940 | 3 | 0 | 0.8351 |
| 7 | CM AWAIT | 0.0066 | 0.1187 | 4 | 0 | 0.0132 |
| 8 | CR AWAIT | 0.2123 | 0.9653 | 6 | 0 | 0.4247 |
| 9 | CO AWAIT | 0.2281 | 1.1222 | 9 | 0 | 0.4563 |
| 10 | IMPR AWAIT | 0.0856 | 0.5094 | 5 | 0 | 0.1713 |
| 11 | FOUR AWAIT | 0.0025 | 0.0695 | 3 | 0 | 0.0050 |
| 12 | FIRM AWAIT | 0.0000 | 0.0000 | 1 | 0 | 0.0000 |
| 13 | PIST AWAIT | 0.0113 | 0.1228 | 2 | 0 | 0.0227 |
| 14 | FLA AWAIT | 0.0141 | 0.1557 | 3 | 0 | 0.0281 |
| 15 | DEUC AWAIT | 0.5091 | 1.7776 | 10 | 0 | 1.0182 |
| 16 | QUAR AWAIT | 0.0052 | 0.0852 | 2 | 0 | 0.0103 |
| 17 | HELI AWAIT | 0.0827 | 0.4639 | 6 | 0 | 0.1654 |
| 18 | GN AWAIT | 0.0000 | 0.0000 | 0 | 0 | 0.0000 |
| 19 | | 0.0000 | 0.0000 | 0 | 0 | 0.0000 |
| 20 | | 0.0000 | 0.0000 | 0 | 0 | 0.0000 |
| 21 | CALENDAR | 8.2753 | 13.4519 | 61 | 1 | 0.1035 |

RESOURCE STATISTICS

| RESOURCE
NUMBER | RESOURCE
LABEL | CURRENT
CAPACITY | AVERAGE
UTILIZATION | STANDARD
DEVIATION | MAXIMUM
UTILIZATION | CURRENT
UTILIZATION |
|--------------------|-------------------|---------------------|------------------------|-----------------------|------------------------|------------------------|
| 1 | DLN | 1 | 0.0167 | 0.1280 | 1 | 0 |
| 2 | NLN | 1 | 0.0167 | 0.1280 | 1 | 0 |

| | | | | | | |
|----|----------|---|--------|--------|---|---|
| 3 | ST_1 | 3 | 0.2756 | 0.8648 | 3 | 0 |
| 4 | ST_2 | 6 | 0.5913 | 1.7119 | 6 | 0 |
| 5 | REMT | 4 | 0.3806 | 1.1482 | 4 | 0 |
| 6 | LOC | 1 | 0.0705 | 0.2561 | 1 | 0 |
| 7 | MEDI | 4 | 0.0607 | 0.4153 | 4 | 0 |
| 8 | RADI | 1 | 0.0550 | 0.2281 | 1 | 0 |
| 9 | OPER | 1 | 0.0500 | 0.2179 | 1 | 0 |
| 10 | IMPROLIT | 1 | 0.0450 | 0.2073 | 1 | 0 |
| 11 | FOUR_H | 1 | 0.0100 | 0.0995 | 1 | 0 |
| 12 | FIRMAN | 1 | 0.0150 | 0.1215 | 1 | 0 |
| 13 | PISTOL | 1 | 0.0505 | 0.2189 | 1 | 0 |
| 14 | FLA | 1 | 0.0603 | 0.2380 | 1 | 0 |
| 15 | DEUCE | 1 | 0.0951 | 0.2933 | 1 | 0 |
| 16 | QUARTER | 2 | 0.0754 | 0.2919 | 2 | 0 |
| 17 | HELI | 1 | 0.0750 | 0.2634 | 1 | 0 |

| RESOURCE
NUMBER | RESOURCE
LABEL | CURRENT
AVAILABLE | AVERAGE
AVAILABLE | MINIMUM
AVAILABLE | MAXIMUM
AVAILABLE |
|--------------------|-------------------|----------------------|----------------------|----------------------|----------------------|
| 1 | DLN | 1 | 0.9833 | 0 | 1 |
| 2 | NLN | 1 | 0.9833 | 0 | 1 |
| 3 | ST_1 | 3 | 2.7230 | 0 | 3 |
| 4 | ST_2 | 6 | 5.4080 | 0 | 6 |
| 5 | REMT | 4 | 3.6190 | 0 | 4 |
| 6 | LOC | 1 | 0.9294 | 0 | 1 |
| 7 | MEDI | 4 | 3.9387 | 0 | 4 |
| 8 | RADI | 1 | 0.9449 | 0 | 1 |
| 9 | OPER | 1 | 0.9500 | 0 | 1 |
| 10 | IMPROLI | 1 | 0.9550 | 0 | 1 |
| 11 | FOUR_H | 1 | 0.9900 | 0 | 1 |
| 12 | FIRMAN | 1 | 0.9850 | 0 | 1 |
| 13 | PISTOL | 1 | 0.9495 | 0 | 1 |
| 14 | FLA | 1 | 0.9397 | 0 | 1 |
| 15 | DEUCE | 1 | 0.9049 | 0 | 1 |
| 16 | QUARTER | 2 | 1.9239 | 0 | 2 |
| 17 | HELI | 1 | 0.9250 | 0 | 1 |

GATE STATISTICS

| GATE
NUMBER | GATE
LABEL | CURRENT
STATUS | PCT. OF
TIME OPEN |
|----------------|---------------|-------------------|----------------------|
| 1 | GNET | OPEN | -0.5708 |

Appendix D

SIMULATION IMPROVEMENT PROCEDURE

The simulation improvement procedure requires an initial EFMB strategy to be determined. The EFMB simulation is performed with these initial parameters and the initial performance measure is obtained. The procedure consists of two improvement components. The schedule improvement procedure is first performed followed by the resource improvement procedure.

Input: An EFMB strategy (schedule and resource levels)

Output: An EFMB strategy having the smallest performance measure (sum of the total average late and slack times)

Start: Examine Simulation Results of Initial EFMB Strategy

Initialization

P:= performance measure, C:= {C₁, ..., C_j} (comment: initialize P to the value of the simulation performance measure, initialize C to the set of all groups that have at least one late and slack time day)

Improvement Procedure

```
while C ≠ { } do                (comment: Schedule Improvement)
begin
  If changing stations between these days may improve P
  then
    If improvement still possible after considering the side effects,
    then
      make the changes and conduct the new simulation
      If new P > current P
      then
        goto initialization
      else
        eliminate group from consideration, C:={C \ Cj}
      endif
    else
      eliminate group from consideration, C:={C \ Cj}
    endif
  else
    eliminate group from consideration, C:={C \ Cj}
  endif
end
end
```

```
If changing the resource levels may improve P    (comment: Resource
                                                    Improvement)
  then
    make the changes and conduct the new simulation
    If the new P > current P
      then
        goto initialization
      else
        endif
    else
  endif
```

Stop: Current EFMB strategy cannot be improved under this procedure and the given input.

Appendix E

TABULATED SIMULATION RESULTS

E.1 60 Candidate EFMB Test Results

RESULTS OF STRATEGIES WITH VARYING RESOURCES
(best strategy is FMO5)

| STRATEGY | | AVERAGE TOTAL | | RESOURCE LEVELS | | | | |
|----------|-----------|---------------|--------|-----------------|---|---|---|---|
| NAME | LATE TIME | SLACK TIME | TOTAL | A | B | C | D | E |
| PMO | 10.076 | 13.256 | 23.332 | 1 | 1 | 1 | 2 | 5 |
| FMO1 | 3.550 | 17.138 | 20.688 | 3 | 2 | 2 | 3 | 6 |
| FMO2 | 24.832 | 8.920 | 33.752 | 1 | 2 | 2 | 1 | 4 |
| FMO3 | 20.856 | 11.826 | 32.682 | 3 | 1 | 2 | 1 | 6 |
| FMO4 | 8.189 | 12.404 | 20.593 | 1 | 1 | 2 | 3 | 4 |
| FMO5 | 5.188 | 12.570 | 17.758 | 3 | 2 | 1 | 3 | 4 |
| FMO6 | 23.858 | 11.621 | 35.479 | 1 | 2 | 1 | 1 | 6 |
| FMO7 | 21.764 | 9.007 | 30.771 | 3 | 1 | 1 | 1 | 4 |
| FMO8 | 7.866 | 16.563 | 24.429 | 1 | 1 | 1 | 3 | 6 |

Schedule for Resource Problem (PMO)

7,6,1,10,5,4,2,20,3,30,8,9

1,7,6,10,5,3,2,20,4,30,8,9

1,6,3,10,7,5,2,20,4,30,8,9

Resource Codes

A-2 1/2 ton truck tasks
(ESW)

B-Helicopter task (ESW)

C-1 1/4 ton truck tasks
(ESW)

D-number of survival
training stations

E -number of emergency
medical treatment stations

RESULTS OF STRATEGIES WITH THREE 20 CANDIDATE GROUPS
(best strategy is SFMO6R)

LEDGEND:

| <u>SCHEDULE CODE</u> | <u>EVENT</u> |
|----------------------|-------------------------------------|
| 1 | DAY LAND NAVIGATION |
| 2 | NIGHT LAND NAVIGATION |
| 3 | SURVIVAL TRAINING |
| 4 | EMERGENCY MEDICAL TREATMENT AND CPR |
| 5 | LITTER OBSTACLE COURSE |
| 6 | COMMUNICATIONS |
| 7 | EVACUATION OF SICK AND WOUNDED |
| 8 | ROADMARCH |
| 9 | ALL STATIONS COMPLETE |
| 10 | END OF DAY ONE TRAINING |
| 20 | END OF DAY TWO TRAINING |
| 30 | END OF DAY THREE TRAINING |

INITIAL SIMULATIONS

| <u>STRATEGY</u> | <u>AVERAGE TOTAL</u> | | | <u>SCHEDULE</u> |
|------------------------------|----------------------|-------------------|--------------|----------------------------|
| <u>NAME</u> | <u>LATE TIME</u> | <u>SLACK TIME</u> | <u>TOTAL</u> | |
| SFMO | 5.188 | 12.570 | 17.758 | 7,6,1,10,5,4,2,20,3,30,8,9 |
| Present Method of Operations | | | | 1,7,6,10,5,3,2,20,4,30,8,9 |
| | | | | 1,6,3,10,7,5,2,20,4,30,8,9 |
| SFMO1 | 0.439 | 17.945 | 18.382 | 6,5,10,7,4,2,20,3,1,30,8,9 |
| Shortest Stations First | | | | 5,6,10,4,7,2,20,1,3,30,8,9 |
| | | | | 7,4,10,3,1,2,20,6,5,30,8,9 |
| SFMO2 | 0.373 | 17.942 | 18.315 | 1,3,2,10,4,7,20,5,6,30,8,9 |
| Longest Stations First | | | | 3,1,2,10,7,4,20,6,5,30,8,9 |
| | | | | 4,7,2,10,5,6,20,1,3,30,8,9 |
| SFMO3 | 0.405 | 19.159 | 19.565 | 1,3,2,10,4,7,20,5,6,30,8,9 |
| Longest First-Separation | | | | 4,7,2,10,5,6,20,1,3,30,8,9 |
| | | | | 5,6,2,10,1,3,20,4,7,30,8,9 |
| SFMO4 | 0.420 | 19.274 | 19.694 | 6,5,10,7,4,2,20,3,1,30,8,9 |
| Shortest First-Separation | | | | 7,4,10,3,1,2,20,6,5,30,8,9 |
| | | | | 3,1,10,6,5,2,20,7,4,30,8,9 |

| STRATEGY | AVERAGE TOTAL | | | |
|----------|---------------|------------|--------|----------------------------|
| NAME | LATE TIME | SLACK TIME | TOTAL | SCHEDULE |
| SFMO5 | 0.0 | 18.478 | 18.478 | 3,5,10,4,1,2,20,6,7,30,8,9 |
| Packing | | | | 4,1,10,6,7,2,20,3,5,30,8,9 |
| | | | | 6,7,10,3,5,2,20,4,1,30,8,9 |

IMPROVEMENT PROCEDURE SIMULATIONS

| | | | | |
|--------|-------|--------|--------|----------------------------|
| SFMO6 | 3.767 | 12.579 | 16.346 | 7,6,1,10,5,4,2,20,3,30,8,9 |
| | | | | 1,7,6,10,5,3,2,20,4,30,8,9 |
| | | | | 1,6,7,10,3,5,2,20,4,30,8,9 |
| SFMO6A | 1.758 | 13.181 | 14.939 | 7,6,1,10,5,4,2,20,3,30,8,9 |
| | | | | 5,7,6,10,1,3,2,20,4,30,8,9 |
| | | | | 1,6,7,10,3,5,2,20,4,30,8,9 |
| SFMO6B | 0.829 | 13.509 | 14.338 | 7,6,1,10,5,4,2,20,3,30,8,9 |
| | | | | 5,7,6,10,1,3,2,20,4,30,8,9 |
| | | | | 6,5,7,10,3,1,2,20,4,30,8,9 |

| | | | | RESOURCE LEVEL | | | | |
|--------|-------|--------|--------|----------------|---|---|---|---|
| | | | | A | B | C | D | E |
| SFMO6B | 0.507 | 12.725 | 13.231 | 1 | 1 | 2 | 3 | 4 |

RESULTS OF STRATEGIES WITH FOUR 15 CANDIDATE GROUPS
(best strategy is BFMO9D)

LEDGEND:

| <u>SCHEDULE CODE</u> | <u>EVENT</u> |
|----------------------|-------------------------------------|
| 1 | DAY LAND NAVIGATION |
| 2 | NIGHT LAND NAVIGATION |
| 3 | SURVIVAL TRAINING |
| 4 | EMERGENCY MEDICAL TREATMENT AND CPR |
| 5 | LITTER OBSTACLE COURSE |
| 6 | COMMUNICATIONS |
| 7 | EVACUATION OF SICK AND WOUNDED |
| 8 | ROADMARCH |
| 9 | ALL STATIONS COMPLETE |
| 10 | END OF DAY ONE TRAINING |
| 20 | END OF DAY TWO TRAINING |
| 30 | END OF DAY THREE TRAINING |

INITIAL SIMULATIONS

| <u>STRATEGY</u> | <u>AVERAGE TOTAL</u> | | | <u>SCHEDULE</u> |
|--------------------------|----------------------|-------------------|--------------|----------------------------|
| <u>NAME</u> | <u>LATE TIME</u> | <u>SLACK TIME</u> | <u>TOTAL</u> | |
| BPMO | 2.465 | 31.308 | 33.772 | 7,6,1,10,5,4,2,20,3,30,8,9 |
| Baseline | | | | 1,3,6,10,7,5,2,20,4,30,8,9 |
| | | | | 1,6,3,10,7,5,2,20,4,30,8,9 |
| | | | | 6,5,1,10,4,3,2,20,7,30,8,9 |
| BFMO1 | 0.0 | 37.530 | 37.530 | 6,5,10,7,4,2,20,3,1,30,8,9 |
| Shortest Stations First | | | | 5,6,10,4,7,2,20,1,3,30,8,9 |
| | | | | 7,4,10,3,1,2,20,5,6,30,8,9 |
| | | | | 4,7,10,1,5,2,20,6,5,30,8,9 |
| BFMO2 | 0.0 | 37.540 | 37.540 | 1,3,2,10,4,7,20,5,6,30,8,9 |
| Longest Stations First | | | | 3,1,2,10,7,4,20,6,5,30,8,9 |
| | | | | 4,7,2,10,5,6,20,1,3,30,8,9 |
| | | | | 7,4,2,10,6,5,20,3,1,30,8,9 |
| BFMO3 | 0.0 | 37.128 | 37.128 | 1,3,2,10,4,7,20,5,6,30,8,9 |
| Longest First-Separation | | | | 4,7,2,10,5,6,20,1,3,30,8,9 |
| | | | | 5,6,2,10,1,3,30,4,7,30,8,9 |
| | | | | 7,4,2,10,3,1,20,5,6,30,8,9 |

| STRATEGY | AVERAGE TOTAL | | | SCHEDULE |
|---------------------------|---------------|------------|--------|----------------------------|
| NAME | LATE TIME | SLACK TIME | TOTAL | |
| BFMO4 | 0.906 | 28.219 | 29.125 | 6,5,10,7,4,2,20,3,1,30,8,9 |
| Shortest First-Separation | | | | 7,4,10,3,1,2,20,6,5,30,8,9 |
| | | | | 3,1,10,6,5,2,20,7,4,30,8,9 |
| | | | | 6,5,10,1,3,2,20,7,4,30,8,9 |
| BFMO5 | 0.0 | 38.265 | 38.265 | 3,6,10,1,5,2,20,4,7,30,8,9 |
| Packing | | | | 1,5,10,4,7,2,20,3,6,30,8,9 |
| | | | | 4,7,10,3,6,2,20,1,5,30,8,9 |
| | | | | 6,3,10,5,1,2,20,7,4,30,8,9 |

IMPROVEMENT PROCEDURE SIMULATIONS

| | | | | |
|--------|-------|--------|--------|----------------------------|
| BFMO6 | 0.362 | 30.016 | 30.377 | 7,6,5,10,1,4,2,20,3,30,8,9 |
| | | | | 1,7,6,10,5,3,2,20,4,30,8,9 |
| | | | | 5,6,7,10,3,1,2,20,4,30,8,9 |
| | | | | 6,5,1,10,4,7,2,20,3,30,8,9 |
| BFMO7 | 7.571 | 0.926 | 8.497 | 7,6,1,10,5,4,3,2,20,8,9 |
| | | | | 1,7,5,10,6,3,4,2,20,8,9 |
| | | | | 5,6,7,10,3,1,4,2,20,8,9 |
| | | | | 6,5,1,10,4,7,3,2,20,8,9 |
| BFMO8 | 4.860 | 1.464 | 6.324 | 7,6,1,10,5,4,3,2,20,8,9 |
| | | | | 1,7,5,10,6,3,4,2,20,8,9 |
| | | | | 5,4,7,10,3,1,6,2,20,8,9 |
| | | | | 6,5,1,10,4,7,3,2,20,8,9 |
| BFMO9 | 3.201 | 2.308 | 5.508 | 7,6,3,10,5,4,1,2,20,8,9 |
| | | | | 1,7,5,10,6,3,4,2,20,8,9 |
| | | | | 5,4,7,10,3,1,6,2,20,8,9 |
| | | | | 6,5,1,10,4,7,3,2,20,8,9 |
| BFMO9A | 3.130 | 2.236 | 5.366 | 7,6,3,10,5,4,1,2,20,8,9 |
| | | | | 1,7,4,10,6,3,5,2,20,8,9 |
| | | | | 5,4,7,10,3,1,6,2,20,8,9 |
| | | | | 6,5,1,10,4,7,3,2,20,8,9 |
| FMO9D | 2.332 | 1.528 | 3.844 | 4,6,3,10,7,5,1,2,20,6,9 |
| | | | | 1,7,4,10,6,3,5,2,20,8,9 |
| | | | | 5,4,7,10,3,1,6,2,20,8,9 |
| | | | | 6,5,1,10,4,7,3,2,20,8,9 |

RESULTS OF SENSITIVITY ANALYSIS ON THE BEST SCHEDULES (BOTH THREE AND FOUR GROUP STRATEGIES)

(best strategy is still SFMO6R for the three group strategy; it is still BFM09D for the four group strategy; resource levels also remain the same)

LEDGEND:

| <u>SCHEDULE CODE</u> | <u>EVENT</u> |
|----------------------|-------------------------------------|
| 1 | DAY LAND NAVIGATION |
| 2 | NIGHT LAND NAVIGATION |
| 3 | SURVIVAL TRAINING |
| 4 | EMERGENCY MEDICAL TREATMENT AND CPR |
| 5 | LITTER OBSTACLE COURSE |
| 6 | COMMUNICATIONS |
| 7 | EVACUATION OF SICK AND WOUNDED |
| 8 | ROADMARCH |
| 9 | ALL STATIONS COMPLETE |
| 10 | END OF DAY ONE TRAINING |
| 20 | END OF DAY TWO TRAINING |
| 30 | END OF DAY THREE TRAINING |

| <u>STRATEGY</u> | <u>AVERAGE TOTAL</u> | | | <u>SCHEDULE</u> |
|-----------------|----------------------|-------------------|--------------|--|
| <u>NAME</u> | <u>LATE TIME</u> | <u>SLACK TIME</u> | <u>TOTAL</u> | |
| SFMO6R | 3.182 | 10.410 | 13.592 | 7,6,5,10,4,1,2,20,3,30,8,9
5,7,6,10,1,3,2,20,4,30,8,9
6,5,7,10,3,1,2,20,4,30,8,9 |
| BFM19D | 5.300 | 0.952 | 6.252 | 4,6,3,10,7,5,1,2,20,8,9
1,7,4,10,6,3,5,2,20,8,9
5,4,7,10,3,1,6,2,20,8,9
6,5,1,10,4,7,3,2,20,8,9 |

E.2 180 Candidate EFMB Test Results

RESULTS OF STRATEGIES WITH THREE 60 CANDIDATE GROUPS
(best strategy is G3NEW)

| STRATEGY
NAME | AVERAGE TOTAL | | TOTAL | RESOURCE LEVELS | | | | |
|------------------|---------------|------------|--------|-----------------|---|---|---|---|
| | LATE TIME | SLACK TIME | | A | B | C | D | E |
| G3FM1 | 35.353 | 5.27 | 40.623 | 3 | 2 | 2 | 3 | 6 |
| G3FM4 | 53.781 | 0 | 53.781 | 1 | 1 | 2 | 3 | 4 |
| G3FM5 | 46.582 | 0 | 46.582 | 3 | 2 | 1 | 3 | 4 |
| G3NEW | 35.33 | .71 | 36.04 | 3 | 2 | 2 | 3 | 5 |

Schedule for Three Group 180 Candidate Problem Resource Codes

1,7,10,5,6,20,4,2,30,3,40,8,9
5,6,10,4,2,20,3,30,1,7,40,8,9
3,10,1,7,20,5,6,30,4,2,40,8,9

A-2 1/2 ton truck tasks
(ESW)
B-Helicopter task (ESW)
C-1 1/4 ton truck task
(ESW)
D-number of survival
training stations
E-number of emergency
medical treatment stations

RESULTS OF STRATEGIES WITH FOUR 45 CANDIDATE GROUPS
(best strategy is G4NEW)

| STRATEGY
NAME | AVERAGE TOTAL | | | RESOURCE LEVELS | | | | |
|------------------|---------------|------------|--------|-----------------|---|---|---|---|
| | LATE TIME | SLACK TIME | TOTAL | A | B | C | D | E |
| G4FM1 | 16.298 | 13.533 | 29.831 | 3 | 2 | 2 | 3 | 6 |
| G4FM4 | 28.893 | 1.351 | 30.245 | 1 | 1 | 2 | 3 | 4 |
| G4FM5 | 21.691 | 1.351 | 23.042 | 3 | 2 | 1 | 3 | 4 |
| G4NEW | 16.312 | 1.373 | 17.685 | 3 | 2 | 2 | 3 | 4 |

Schedule for Four Group 180 Candidate Problem Resource Codes

1,7,10,4,2,20,3,30,5,6,40,8,9
 5,6,10,1,7,20,4,2,30,3,40,8,9
 3,10,5,6,20,1,7,30,4,2,40,8,9
 4,2,10,3,20,5,6,30,1,7,40,8,9

A-2 1/2 ton truck tasks
 (ESW)
 B-Helicopter tasks (ESW)
 C-1 1/4 ton truck tasks
 (ESW)
 D-number of survival
 stations
 E-number of emergency
 medical treatment stations

Appendix F

SLAM SIMULATION PROGRAM

```
; *****  
; THIS IS THE EXPERT FIELD MEDICAL BADGE TEST SLAM SIMULATION PROGRAM.  
; IT INTERACTS WITH SEVERAL COMPILED FORTRAN SUBROUTINES AND  
; FUNCTIONS (DESCRIBED IN THE INTRODUCTION TO THE FORTRAN CODE).  
; THIS CODE WAS DEVELOPED UNDER SLAM II, VERSION 4.03 (COPYRIGHT 1983),  
; AND THE FORTRAN CODE WAS DEVELOPED AND COMPILED UNDER VS FORTRAN,  
; VERSION 2.4. AN IBM 3081 MAINFRAME COMPUTER (OPERATING SYSTEM  
; VM/XA SP 2.1) WAS USED FOR THIS PROJECT WITH A WORK STATION TERMINAL  
; CAPACITY OF 7M.  
; *****  
;   
; GEN,JSEES,EFMB,05/19/92,30,NO,NO,YES/YES,NO,YES/S;  
; LIMITS,20,22,40000;  
;   
; STATISTICS BLOCK  
; *****  
; THE BELOW DEFINED STATISTICAL VARIABLES ARE USED TO FACILITATE  
; STATISTICS COLLECTION OVER THE 30 SIMULATED PERFORMANCE TESTS.  
; THEY INTERACT WITH THE FORTRAN OUTPUT SUBROUTINE TO OBTAIN  
; OBSERVATIONS FOR EACH RUN, AND AT THE END OF THE 30 RUNS, PROVIDE  
; THE AVERAGE STATISTICS. THE LAST TWO STATISTICS, SLACK TIME AND  
; LATE TIME, OBTAIN THE APPROPRIATE OBSERVATIONS WITHIN EACH  
; SIMULATION RUN THROUGH INTERACTION WITH THE FORTRAN FUNCTION  
; USERF.  
;   
;   
; STAT,1,AVE EFMB TIME;  
; STAT,2,AVE LATE TIME;  
; STAT,3,AVE NUM LATE;  
; STAT,4,AVE SLACK TIME;  
; STAT,5,AVE NUM SLACK;  
; STAT,6,GROUP DLN___1;  
; STAT,7,GROUP NLN___2;  
; STAT,8,GROUP ST___3;  
; STAT,9,GROUP EMT___4;  
; STAT,10,GROUP LOC___5;  
; STAT,11,GROUP COM___6;  
; STAT,12,GROUP ESW___7;  
; STAT,13,GROUP RM___8;  
; STAT,14,WAIT DLN;  
; STAT,15,WAIT NLN;
```

```

STAT,16,WAIT ST1;
STAT,17,WAIT ST2;
STAT,18,WAIT EMT;
STAT,19,WAIT LOC;
STAT,20,WAIT CM;
STAT,21,WAIT CR;
STAT,22,WAIT CO;
STAT,23,WAIT IMPR;
STAT,24,WAIT FOUR;
STAT,25,WAIT FIRM;
STAT,26,WAIT PIST;
STAT,27,WAIT FLA;
STAT,28,WAIT DEUC;
STAT,29,WAIT QUAR;
STAT,30,WAIT HLLI;
STAT,31,SLACK TIME;
STAT,32,LATE TIME;
;
INIT,0,120,NO/31,YES,YES;
;
ARRAY(1,13);
ARRAY(2,13);
ARRAY(3,13);
ARRAY(4,13);
;
; EQUIVALENCE BLOCK
*****
; SLAM GLOBAL VARIABLES AND CANDIDATE ATTRIBUTES ARE EQUIVALENCED
; TO VARIABLE NAMES TO MAKE THE SIMULATION CODE MORE READABLE.
; THESE VARIABLE NAMES ARE USED EVERYWHERE THE SYNTAX OF THE SLAM
; SIMULATION LANGUAGE ALLOWS.
;
;
; GLOBAL VARIABLE EQUIVALENCES
;
EQUIVALENCE/XX(1),NUM_OF_GROUPS;
EQUIVALENCE/XX(2),CANDIDATES_PER_GROUP;
EQUIVALENCE/XX(3),GATE_COUNTER;
EQUIVALENCE/XX(4),DAILY_TNG_TIME;
EQUIVALENCE/XX(5),DLN_COUNTER;
EQUIVALENCE/XX(6),NLN_COUNTER;
EQUIVALENCE/XX(7),LOC_COUNTER;
EQUIVALENCE/XX(8),GATE_TIME;
;
; CANDIDATE ATTRIBUTE EQUIVALENCES
EQUIVALENCE/ATRI(1),GROUP_NUM;
EQUIVALENCE/ATRI(2),GROUP_SIZE;
EQUIVALENCE/ATRI(3),STATION_NUM;
EQUIVALENCE/ATRI(4),TOT_TL_IN_SYS;
EQUIVALENCE/ARRAY(GROUP_NUM,STATION_NUM),NEXT_STA;

```

```

EQUIVALENCE/ATRIB(6),TOT_TM_DLN;
EQUIVALENCE/ATRIB(7),TOT_TM_NLN;
EQUIVALENCE/ATRIB(8),TOT_TM_ST;
EQUIVALENCE/ATRIB(9),TOT_TM_EMT;
EQUIVALENCE/ATRIB(10),CPR;
EQUIVALENCE/ATRIB(11),EMT;
EQUIVALENCE/ATRIB(12),TOT_TM_LOC;
EQUIVALENCE/ATRIB(14),TOT_TM_COM;
EQUIVALENCE/ATRIB(15),MEDIVAC;
EQUIVALENCE/ATRIB(16),RADIO_NET;
EQUIVALENCE/ATRIB(17),OPERATE;
EQUIVALENCE/ATRIB(18),TOT_TM_ESW;
EQUIVALENCE/ATRIB(19),ESWC;
EQUIVALENCE/ATRIB(20),TOT_TM_RM;
;
;
NETWORK;
; RESOURCE BLOCK
*****
; THE RESOURCES ESTABLISH THE CAPACITY OF EACH OF THE STATIONS/TASKS
; IN THE EFMB PERFORMANCE TEST. RESOURCES WITH A CAPACITY OF ZERO
; ARE SET BY THE USER THROUGH THE INITIALIZATION SUBROUTINE.
;
;
RESOURCE/1,DLN(2),1;
RESOURCE/2,NLN(2),2;
RESOURCE/3,ST_1(0),3;
RESOURCE/4,ST_2(0),4;
RESOURCE/5,REMT(0),5;
RESOURCE/6,LOC(1),6;
RESOURCE/7,MEDI(4),7;
RESOURCE/8,RADI(1),8;
RESOURCE/9,OPER(1),9;
RESOURCE/10,IMPROLIT(1),10;
RESOURCE/11,FOUR_H(1),11;
RESOURCE/12,FIRMAN(1),12;
RESOURCE/13,PISTOL(1),13;
RESOURCE/14,FLA(1),14;
RESOURCE/15,DEUCE(0),15;
RESOURCE/16,QUARTER(0),16;
RESOURCE/17,HELI(0),17;
;
; DAILY TRAINING COMPLETION GATE*****
;
GATE/1,GNET,OPEN,18;
;
;
;

```



```

; DAILY TRAINING COMPLETION NETWORK*****
; THE SIMULATION STARTS AT TIME ZERO AND CONTINUES UNTIL THE DAILY
; TRAINING TIME IS REACHED. THEN THE DAILY TRAINING GATE CLOSSES AND
; THE CLOSING TIME IS RECORDED. THIS CONTINUES FOR THE FIVE DAYS
; OF THE SIMULATED EFMB TEST. DAILY CLOSING TIMES ARE RECORDED AND
; ARE INCLUDED IN THE OUTPUT REPORTS. NOTE: IN ORDER FOR THE
; INITIAL TRAINING GATE TO CLOSE AT THE PROPER TIME, THE DAILY
; TRAINING TIME IS DECREASED BY .11 HOURS. THIS ALLOWS THE PROPER
; ADVANCEMENT OF THE SIMULATION CLOCK UPON EXECUTION OF THE
; CONDITIONAL BRANCHING.
;
;
; CREATE,,0,,1,1;
RTN GOON,1;
ACT,,1,TNOW.GE.DAILY_TNG_TIME-.11,CLOS;
ACT,,1,TNOW.LT.DAILY_TNG_TIME-.11,RTN;
CLOS CLOSE,GNET;
ASSIGN,GATE_COUNTER=GATE_COUNTER+1,
GATE_TIME=TNOW;
GOON,1;
ACT,,GATE_COUNTER.EQ.1,TM1;
ACT,,GATE_COUNTER.EQ.2,TM2;
ACT,,GATE_COUNTER.EQ.3,TM3;
ACT,,GATE_COUNTER.EQ.4,TM4;
ACT,,GATE_COUNTER.EQ.5,TM5;
TM1 COLCT,FIRST,END 1ST DAY TNG;
ACT,,,TM6;
TM2 COLCT,FIRST,END 2ND DAY TNG;
ACT,,,TM6;
TM3 COLCT,FIRST,END 3RD DAY TNG;
ACT,,,TM6;
TM4 COLCT,FIRST,END 4TH DAY TNG;
ACT,,,TM6;
TM5 COLCT,FIRST,END 5TH DAY TNG;
TM6 GOON,1;
ACT,24-DAILY_TNG_TIME;
OPEN,GNET;
ACT,DAILY_TNG_TIME,,CLOS;
;
; STARTING BLOCK *****
; CANDIDATES ENTER FROM THE FORTRAN SUBROUTINE INTLC AND FORM INTO
; THEIR GROUPS BEFORE MOVING TO THE CONTROL CHECKS AND ROUTING
; BLOCK.
;
; ENTER,1;
STO ASSIGN,TOT_TM_IN_SYS=TNOW;
BATCH,4/1,ATRB(2),,LAST,AI.L(5);
ACT...NS;

```

```

; CONTROL CHECKS AND ROUTING BLOCK *****
; A SERIES OF LOGICAL BRANCHING IS ENCOUNTERED TO DETERMINE IF THE
; DAY'S TRAINING HAS BEEN COMPLETED AND WHETHER LATE OR SLACK
; STATISTICS SHOULD BE COLLECTED. IF THE DAY'S TRAINING HAS BEEN
; COMPLETED, THE SCHEDULE IS CHECKED FOR FEASIBILITY, AND THE
; GROUPS ARE PLACED IN AN EXPLICIT WAITING BLOCK UNTIL THE
; BEGINNING OF THE NEXT DAY'S TRAINING.
;
;
NS GOON,1;
  ACT,,TNOW.EQ.0,NS5;
  ACT,,TNOW.NE.0,NS4;
;
; IF THE SIMULATION HAS JUST
; STARTED, GO TO THE STATION JUST
; COMPLETED CHECK.
NS4 GOON,1;
  ACT,,NEXT_STA.EQ.2,NSS;
  ACT,,NEXT_STA.NE.2,NS5;
;
; THIS IS THE STATION JUST
; COMPLETED. IF IT IS NLN, DON'T
; COLLECT STATISTICS.
NS5 GOON,1;
  ACT,,NNGAT(1).EQ.0,NSS;
  ACT,,NNGAT(1).NE.0,NS2;
;
; IF THE TRAINING WINDOW FOR THE
; DAY HAS ENDED (IE. THE GATE IS
; CLOSED), COLLECT A LATENESS
; OBSERVATION, OTHERWISE
; CONTINUE.
NS2 ASSIGN,TRIB(13)=GATE_TIME;
  ASSIGN,TRIB(13)=TNOW-TRIB(13);
  ACT,USERF(20);
;
;
NSS ASSIGN,STATION_NUM=STATION_NUM+1;THE GROUPS' STATION_NUM ARE
NS1 GOON, 1;
  ACT,,NEXT_STA.EQ.10,ERLY;
  ACT,,NEXT_STA.EQ.20,ERLY;
  ACT,,NEXT_STA.EQ.30,ERLY;
  ACT,,NEXT_STA.EQ.40,ERLY;
  ACT,,NEXT_STA.EQ.9,J1;
  ACT,,NEXT_STA.EQ.2,ERLY;
  ACT,,NEXT_STA.NE.2,GN;
;
;
; IF THE CURRENT SCHEDULE
; POSITION INDICATES THE END OF
; A DAY'S TRAINING OR THE NLN
; STATION, GO TO THE SLACK TIME
; STATISTICS LOGIC BLOCK. OTHER-
; WISE, GO TO THE NEXT STATION
; ROUTING BLOCK. IF ALL
; STATIONS HAVE BEEN COMPLETED,
; GO TO THE NEXT STATION ROUTING
; BLOCK.
;
; SLACK TIME STATISTICS LOGIC BLOCK *****
; GROUPS ARRIVE HERE IF THEY HAVE COMPLETED THEIR ASSIGNED DAILY
; TRAINING PRIOR TO THE END OF THE DESIGNATED WORK DAY, OR IF THE
; NEXT STATION CODE INDICATES THE DAY'S TRAINING HAS BEEN COMPLETED.
; STATISTICS ARE COLLECTED AND THE GROUPS MOVE TO THE EXPLICIT
; SCHEDULE WAITING BLOCK AND SIMULATION FEASIBILITY CHECK
;
;
ERLY GOON,1;
  ACT,,NNGAT(1).EQ.0,GOER;
  ACT,,NNGAT(1).NE.0,GOWA;
;
; DETERMINES WHETHER A STATISTIC
; FOR SLACK TIME IS REQUIRED TO
; COLLECTED.

```

```

GOWA GOON,1;
  ACT,,NEXT_STA.EQ.2,R11;
  ACT,,NEXT_STA.EQ.10,FW1;
  ACT,,NEXT_STA.EQ.20,FW2;
  ACT,,NEXT_STA.EQ.30,FW3;
  ACT,,NEXT_STA.EQ.40,FW4;
;
GOER GOON,1;
  ACT,,TNOW.LE.XX(4),EY1;
  ACT,,TNOW.GT.XX(4),EY2;
EY1 ASSIGN,ATRI(13)=XX(4)-TNOW;
  ACT,,,EY3;
EY2 ASSIGN,ATRI(13)=GATE_TIME+24,
  ATRI(13)=ATRI(13)-TNOW;
EY3 GOON,1;
  ACT,USERF(21),,GOWA;
;
; EXPLICIT SCHEDULE WAITING BLOCK AND END SIMULATION NOW SEQUENCE *****
; THE GROUPS ARRIVE AND WAIT FOR THE NEXT DAY'S TRAINING WINDOW TO
; BEGIN. IF, UPON ARRIVAL, THE NEXT DAY'S TRAINING HAS ALREADY
; BEGUN, THE SCHEDULE IS INFEASIBLE, AND THE USER FUNCTION IS CALLED
; TO END THE SIMULATION.
;
FW1 GOON,1;
  ACT,,TNOW.GE.24,ESN;
  ACT,,TNOW.LT.24,WA1;
WA1 GOON,1;
  ACT,,1,TNOW.LE.23.9,WA1;
  ACT,,1,TNOW.GT.23.9,WNS;
;
FW2 GOON,1;
  ACT,,TNOW.GE.48,ESN;
  ACT,,TNOW.LT.48,WA2;
WA2 GOON,1;
  ACT,,1,TNOW.LE.47.9,WA2;
  ACT,,1,TNOW.GT.47.9,WNS;
;
FW3 GOON,1;
  ACT,,TNOW.GE.72,ESN;
  ACT,,TNOW.LT.72,WA3;
WA3 GOON,1;
  ACT,,1,TNOW.LE.71.9,WA3;
  ACT,,1,TNOW.GT.71.9,WNS;
;
FW4 GOON,1;
  ACT,,TNOW.GE.96,ESN;
  ACT,,TNOW.LT.96,WA4;
;

```

ROUTES CANDIDATES TO NLN OR TO
 AN EXPLICIT SCHEDULE WAITING
 BLOCK.

THE SLACK TIME STATISTIC IS
 CALCULATED AND COLLECTED.

DAY ONE

DAY TWO

DAY THREE

DAY FOUR

```

WA4 GOON,1;
  ACT,.1,TNOW.LE.95.9,WA4;
  ACT,.1,TNOW.GT.95.9,WNS;
;
ESN GOON,1;
  ACT,USERF(22);
;
WNS UNBATCH,5;
  ASSIGN,STATION_NUM=STATION_NUM+1;
  BATCH,4/1,TRIB(2),,LAST,ALL(5);
  ACT,,,NS;
;
;
;
; NIGHT LAND NAVIGATION ROUTING GATE BYPASS *****
; THE CANDIDATES LEAVE THEIR GROUP AND WAIT UNTIL THE END OF THE
; DAILY TRAINING TIME BEFORE MOVING TO THE NLN STATION.
;
;
R11 UNBATCH,5;
  ASSIGN,STATION_NUM=STATION_NUM+1;
  ACT,,,NIT;
NIT GOON,1;
  ACT,.1,NNGAT(1).EQ.0,NIT;
  ACT,.1,NNGAT(1).EQ.1,NLN;
;
; NEXT STATION ROUTING BLOCK *****
; CANDIDATES LEAVE THEIR GROUPS, THEIR SCHEDULES ARE INCREMENTED TO
; INDICATE THEIR NEXT SCHEDULED STATION, AND THEY GO TO THE NEXT
; SCHEDULED STATION.
;
;
GN GOON,1;
J1 UNBATCH,5;
  ASSIGN,STATION_NUM=STATION_NUM+1;
  ACT,,,J2;
J2 GOON,1;
  ACT,,NEXT_STA.EQ.1,DLN;
  ACT,,NEXT_STA.EQ.3,ST;
  ACT,,NEXT_STA.EQ.4,LEMT;
  ACT,,NEXT_STA.EQ.5,LOC;
  ACT,,NEXT_STA.EQ.6,COM;
  ACT,,NEXT_STA.EQ.7,ESW;
  ACT,,NEXT_STA.EQ.8,RM;
  ACT,,NEXT_STA.EQ.9,DATA;
;
; DAY LAND NAVIGATION BLOCK *****
; CANDIDATES ARRIVE AND MOVE IN GROUPS OF TEN TO TWO STARTING

```

```

; POINTS. THEY PERFORM THE DLN AND ASSEMBLE INTO THEIR GROUPS
; BEFORE DEPARTING FOR THE CONTROL CHECKS AND ROUTING BLOCK.
;
;
;
;
DLN ASSIGN,TOT_TM_DLN=TNOW;
ACT,USERF(23); MOVEMENT TIME TO DLN INCLUDED
ASSIGN,DLN_COUNTER=DLN_COUNTER+1;IN DLN STATISTICS
GOON,1;
ACT,,DLN_COUNTER.EQ.CANDIDATES_PER_GROUP,DRS;
ACT,,,DCN;
DRS ASSIGN,GROUP_NUM=0-GROUP_NUM,
DLN_COUNTER=0; NEGATIVE ATTRIBUTE FOR
DCN GOON,1; BATCHING THRESHOLD
ACT,USERF(24); 30 MIN FOR INSTRUCTIONS, MAP
ISSUE, 100 M PACE COURSE
;
D12 BATCH,4/1,10,,HIGH(6),ALL(5);
RDLN AWAIT(1),DLN/1,1;
ACT,,25; 15 MINUTES BETWEEN THE START
FREE,DLN/1; OF EACH GROUP OF 10 CANDIDATES
D3 UNBATCH,5;
ACT,USERF(1); DLN DURATION
D11 GOON,1;
ACT,,GROUP_NUM.EQ.1, D7;
ACT,,GROUP_NUM.EQ.2, D8;
ACT,,GROUP_NUM.EQ.3, D9;
ACT,,GROUP_NUM.EQ.4, D10;
D7 COLCT,INT(4),DLN GP1 FIN__1;
ACT,,,D4;
D8 COLCT,INT(4),DLN GP2 FIN__1;
ACT,,,D4;
D9 COLCT,INT(4),DLN GP3 FIN__1;
ACT,,,D4;
D10 COLCT,INT(4),DLN GP4 FIN__1;
D4 BATCH,4/1,ATRIB(2),LAST,ALL(5);
ACT,USERF(23); MOVEMENT TIME FROM DLN
COLCT,INT(6),AVG GRP TM DLN;
ACT,,,NS;
;
; NIGHT LAND NAVIGATION BLOCK *****
; CANDIDATES ARRIVE AND MOVE IN GROUPS OF TEN TO TWO STARTING POINTS.
; THEY PERFORM THE NLN AND ASSEMBLE INTO THEIR GROUPS BEFORE
; DEPARTING FOR THE CONTROL CHECKS AND ROUTING BLOCK.
;
;
; NLN ASSIGN,ATRIB(13)=NUM_OF_GROUPS*GROUP_SIZE;
ACT,,ATRIB(13).GT.60,ZZ; FOR GROUPS SCHEDULED ON
SEPARATE NIGHTS
; ACT,,ATRIB(13).LE.60,BT1; FOR GROUPS ALL SCHEDULED ON
; THE SAME NIGHT

```

```

BT1  BATCH,,ATRIB(13),,LAST,ALL(5);      ALL START AT THE SAME TIME
      UNBATCH,5;
ZZ   ASSIGN,TOT_TM_NLN=TNOW;
      ACT,USERF(25);                      MOVEMENT TIME TO NLN
;                                         INCLUDED IN NLN STATS
NGO  ASSIGN,NLN_COUNTER=NLN_COUNTER+1;
      GOON,1;
      ACT,,NLN_COUNTER.EQ.CANDIDATES_PER_GROUP,NRS;
      ACT,,,NCN;
NRS  ASSIGN,GROUP_NUM=0-GROUP_NUM,
      NLN_COUNTER=0;                      NEGATIVE ATTRIBUTE FOR
NCN  GOON,1;                              BATCHING THRESHOLD OVERRIDE
      ACT,USERF(26);                      30 MINUTES FOR INSTRUCTIONS
N13  BATCH,4/1,10,,HIGH(7),ALL(5);
RNLN  AWAIT(2),NLN/1;
      ACT,,25;                            15 MINUTES BETWEEN THE START
      FREE,NLN/1,1;                       OF EACH GROUP OF 10 CANDIDATES
N3   UNBATCH,5;
      ACT,USERF(2);                       NLN DURATION
D15  GOON,1;
      ACT,,GROUP_NUM.EQ.1, N16;
      ACT,,GROUP_NUM.EQ.2, N17;
      ACT,,GROUP_NUM.EQ.3, N18;
      ACT,,GROUP_NUM.EQ.4, N19;
N16  COLCT,INT(4),NLN GP1 FIN__2;
      ACT,,,N20;
N17  COLCT,INT(4),NLN GP2 FIN__2;
      ACT,,,N20;
N18  COLCT,INT(4),NLN GP3 FIN__2;
      ACT,,,N20;
N19  COLCT,INT(4),NLN GP4 FIN__2;
N20  BATCH,4/1,ATRIB(2),,LAST,ALL(5);
      ACT,USERF(25);                      MOVEMENT TIME FROM NLN
      COLCT,INT(7),AVG GRP TM NLN;
      ACT,,,NS;
;
; SURVIVAL TRAINING BLOCK *****
; CANDIDATES ARRIVE AND BEGIN TO CONDUCT THE SURVIVAL TRAINING
; STATION ONE AFTER ANOTHER. A CANDIDATE CANNOT BEGIN UNTIL THE
; THE CANDIDATE BEFORE HIM HAS COMPLETED THE FIRST THREE STATIONS.
; THE CANDIDATES ASSEMBLE INTO THEIR GROUPS BEFORE THEY DEPART FOR
; THE CONTROL CHECKS AND ROUTING BLOCK.
;
;
ST   ASSIGN,TOT_TM_ST=TNOW;
RST1  AWAIT(3),ST_1/1;
      ACT,USERF(3);                      ST_1 DURATION
;

```

```

RZ1  GOON,1
      ACT,,NNRSC(4).GT.0,RST2;
      ACT,,1,NNRSC(4).LE.0,RZ1;
RST2  AWAIT(4/1),ST_2/1,BLOCK,1;
      FREE,ST_1/1;
      ACT,USERF(4);
      FREE,ST_2/1;
      ACT,,,S5;
S5    GOON,1;
      ACT,,GROUP_NUM.EQ.1,S7;
      ACT,,GROUP_NUM.EQ.2,S8;
      ACT,,GROUP_NUM.EQ.3,S9;
      ACT,,GROUP_NUM.EQ.4,S10;
S7    COLCT,INT(4),ST GP1 FIN__3;
      ACT,,,S6;
S8    COLCT,INT(4),ST GP2 FIN__3;
      ACT,,,S6;
S9    COLCT,INT(4),ST GP3 FIN__3;
      ACT,,,S6;
S10   COLCT,INT(4),ST GP4 FIN__3;
S6    BATCH,4/1,ATrib(2),LAST,ALI.(5);
      COLCT,INT(8),AVG GRP TM ST;
      ACT,,,NS;
;
; EMERGENCY MEDICAL TRAINING BLOCK *****
; CANDIDATES ARRIVE AND BEGIN THE EMERGENCY MEDICAL TRAINING, FOUR
; WAIT IN THE EMT QUEUE, AND THE REMAINDER MOVE TO THE CPR STATION.
; AFTER ROTATION AND COMPLETION OF BOTH THE EMT AND CPR STATIONS,
; THE CANDIDATES ASSEMBLE INTO THEIR GROUPS BEFORE DEPARTING FOR
; THE CONTROL CHECKS AND ROUTING BLOCK.
;
;
LEMT  ASSIGN,TOT_TM_EMT=TNOW;
REMR  AWAIT(5/4),REMT/1,BALK(G3),1;
      ACT,USERF(6);
      FREE,REMT/1;
EM1   ASSIGN,EMT=EMT+1;
EM2   GOON,1;
      ACT,,CPR.NE.1,G3;
      ACT,,CPR.EQ.1,M3;
G3    GOON,1;
      ACT,,CPR.NE.1.AND.EMT.NE.1,CPR;
      ACT,,CPR.NE.1.AND.EMT.EQ.1,CPR;
      ACT,,1,CPR.EQ.1.AND.EMT.NE.1,REMR;
      ACT,,CPR.EQ.1.AND.EMT.EQ.1,M3;
CPR   GOON,1;
      ASSIGN,CPR=CPR+1;
      ACT,USERF(5),G3;

```

CANDIDATES CANNOT PROCEED
UNTIL A ST_2 RESOURCE IS
AVAILABLE.

ST_2 DURATION

EMT DURATION

CPR DURATION

```

M3  GOON,1;
    ACT,,GROUP_NUM.EQ.1,EM3;
    ACT,,GROUP_NUM.EQ.2,EM4;
    ACT,,GROUP_NUM.EQ.3,EM5;
    ACT,,GROUP_NUM.EQ.4,EM6;
EM3 COLCT,INT(4),EMT GP1 FIN__4;
    ACT,,,M4;
EM4 COLCT,INT(4),EMT GP2 FIN__4;
    ACT,,,M4;
EM5 COLCT,INT(4),EMT GP3 FIN__4;
    ACT,,,M4;
EM6 COLCT,INT(4),EMT GP4 FIN__4;
M4  BATCH,4/1,ATRI(2),,LAST,ALL(5);
    COLCT,INT(9),AVG GRP TM EMT;
    ACT,,,NS;
;
; LITTER OBSTACLE COURSE BLOCK *****
; CANDIDATES ARRIVE AND FORM INTO TEAMS OF FOUR. ONE TEAM AFTER
; ANOTHER, THEY PERFORM THE LITTER OBSTACLE COURSE. THEN THEY
; ASSEMBLE INTO GROUPS BEFORE DEPARTING FOR THE CONTROL CHECKS AND
; ROUTING BLOCK.
;
;
LOC ASSIGN,TOT_TM_LOC=TNOW;
    ACT,USERF(27);                MOVEMENT TIME TO LOC INCLUDED
    ASSIGN,LOC_COUNTER=LOC_COUNTER+1;IN LOC STATISTICS
    GOON,1;
    ACT,,LOC_COUNTER.EQ.CANDIDATES_PER_GROUP,LRS;
    ACT,,,LCN;
LRS ASSIGN,GROUP_NUM=0-GROUP_NUM,
    LOC_COUNTER=0;                NEGATIVE ATRIB FOR BATCHING
    ACT,,,LCN;                    THRESHOLD OVERRIDE
LCN GOON,1;
    ACT,USERF(28);                TIME FOR CANDIDATES TO FORM
L13 BATCH,4/1,4,,HIGH(12),ALL(5); TEAMS AND RECEIVE INSTRUCTIONS
RLOC AWAIT(6),LOC/1;
    ACT,USERF(7);                LOC DURATION
    FREE,LOC/1;
    UNBATCH,5;
    GOON,1;
    ACT,,GROUP_NUM.EQ.1,L9;
    ACT,,GROUP_NUM.EQ.2,L10;
    ACT,,GROUP_NUM.EQ.3,L11;
    ACT,,GROUP_NUM.EQ.4,L12;
L9  COLCT,INT(4),LOC GP1 FIN__5;
    ACT,,,L4;
L10 COLCT,INT(4),LOC GP2 FIN__5;
    ACT,,,L4;

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```

L11 COLCT,INT(4),LOC GP3 FIN__5;
    ACT,,,L4;
L12 COLCT,INT(4),LOC GP4 FIN__5;
L4  BATCH,4/1,ATrib(2),,LAST,ALL(5);
    ACT,USERF(27);
    COLCT,INT(12),AVG GRP TM LOC;
    ACT,,,NS;
;
; COMMUNICATIONS BLOCK *****
; CANDIDATES ARRIVE AND APPROXIMATELY ONE THIRD GO TO EACH OF THE
; THREE TASKS. AFTER PERFORMING EACH TASK AND ROTATING, THEY
; ASSEMBLE INTO GROUPS BEFORE MOVING TO THE CONTROL CHECKS AND
; ROUTING BLOCK.
;
;
COM ASSIGN,TOT_TM_COM=TNOW,1;
C01 GOON,1;
    ACT,,,33,CM;
    ACT,,,33,CR;
    ACT,,,34,CO;
CM  AWAIT(7),MEDI/1;
    ACT,USERF(8); MEDIVAC DURATION
    ASSIGN,MEDIVAC=1;
    FREE,MEDI/1;
    ACT,,,G9;
CR  AWAIT(8),RADI/1;
    ACT,USERF(9); ENTER RADIO NET DURATION
    ASSIGN,RADIO_NET=1;
    FREE/RADI/1;
    ACT,,,G9;
CO  AWAIT(9),OPER/1;
    ACT,USERF(10); OPERATE RADIOS DURATION
    ASSIGN,OPERATE=1;
    FREE,OPER/1;
    ACT,,,G9;
G9  GOON,1;
    ACT,,MEDIVAC.NE.1,CM;
    ACT,,OPERATE.NE.1,CO;
    ACT,,RADIO_NET.NE.1,CR;
    ACT,,MEDIVAC.EQ.1.AND.RADIO_NET.EQ.1.AND.OPERATE.EQ.1,C1;
C1  GOON,1;
    ACT,,GROUP_NUM.EQ.1,C3;
    ACT,,GROUP_NUM.EQ.2,C4;
    ACT,,GROUP_NUM.EQ.3,C5;
    ACT,,GROUP_NUM.EQ.4,C6;
C3  COLCT,INT(4),COM GP1 FIN__6;
    ACT,,,C2;
C4  COLCT,INT(4),COM GP2 FIN__6;

```

```

ACT,,,C2;
C5 COLCT,INT(4),COM GP3 FIN__6;
ACT,,,C2;
C6 COLCT,INT(4),COM GP4 FIN__6;
C2 BATCH,4/1,ATRI(2),,LAST,ALL(5);
COLCT,INT(14),AVG GRP TM COM;
ACT,,,NS;
;
; EVACUATION OF SICK AND WOUNDED BLOCK *****
; CANDIDATES ARRIVE AND APPROXIMATELY ONE EIGHTH GO TO EACH OF THE
; EIGHT TASKS. AFTER PERFORMING EACH TASK AND ROTATING, THEY
; ASSEMBLE INTO THEIR GROUPS BEFORE MOVING TO THE CONTROL CHECKS
; AND ROUTING BLOCK.
;
;
ESW ASSIGN,TOT_TM_ESW=TNOW;
E10 GOON,1;
ACT,,,125,IMPR;
ACT,,,125,FOUR;
ACT,,,125,FIRM;
ACT,,,125,PIST
ACT,,,125,FLA;
ACT,,,125,DEUC;
ACT,,,125,QUAR;
ACT,,,125,HELI;
IMPR AWAIT(10),IMPROLIT/1;
ACT,USERF(11);
ASSIGN,ESWC=ESWC+1;
FREE,IMPROLIT/1,1;
ACT,,ESWC.LE.7,DEUC;
ACT,,ESWC.GT.7,E09;
FOUR AWAIT(11),FOUR_H/1;
ACT,USERF(12);
ASSIGN,ESWC=ESWC+1;
FREE,FOUR_H/1,1;
ACT,,ESWC.LE.7,IMPR;
ACT,,ESWC.GT.7,E09;
FIRM AWAIT(12),FIRMAN/1;
ACT,USERF(13);
ASSIGN,ESWC=ESWC+1;
FREE,FIRMAN/1,1;
ACT,,ESWC.LE.7,FOUR;
ACT,,ESWC.GT.7,E09;
PIST AWAIT(13),PISTOL/1;
ACT,USERF(14);
ASSIGN,ESWC=ESWC+1;
FREE,PISTOL/1,1;
ACT,,ESWC.LE.7,FIRM

```

IMPROVISED LITTER DURATION

FOUR HAND CARRY DURATION

FIREMAN'S CARRY DURATION

PISTOL CARRY DURATION

```

      ACT,,ESWC.GT.7,E09;
FLA  AWAIT(14),FLA/1;
      ACT,USERF(15);
      ASSIGN,ESWC=ESWC+1;
      FREE,FLA/1,1;
      ACT,,ESWC.LE.7,QUAR;
      ACT,,ESWC.GT.7,E09;
DEUC AWAIT(15),DEUCE/1;
      ACT,USERF(16);
      ASSIGN,ESWC=ESWC+1;
      FREE,DEUCE/1,1;
      ACT,,ESWC.LE.7,FLA;
      ACT,,ESWC.GT.7,E09;
QUAR AWAIT(16),QUARTER/1;
      ACT,USERF(17);
      ASSIGN,ESWC=ESWC+1;
      FREE,QUARTER/1,1;
      ACT,,ESWC.LE.7,HELI;
      ACT,,ESWC.GT.7,E09;
HELI AWAIT(17),HELI/1;
      ACT,USERF(18);
      ASSIGN,ESWC=ESWC+1;
      FREE,HELI/1,1;
      ACT,,ESWC.LE.7,PIST;
      ACT,,ESWC.GT.7,E09;
E09  GOON,1;
      ACT,,GROUP_NUM.EQ.1,E11;
      ACT,,GROUP_NUM.EQ.2,E12;
      ACT,,GROUP_NUM.EQ.3,E13;
      ACT,,GROUP_NUM.EQ.4,E14;
E11  COLCT,INT(4),ESW GP1 FIN__7;
      ACT,,,DE;
E12  COLCT,INT(4),ESW GP2 FIN__7;
      ACT,,,DE;
E13  COLCT,INT(4),ESW GP3 FIN__7;
      ACT,,,DE;
E14  COLCT,INT(4),ESW GP4 FIN__7;
DE   BATCH,4/1,ATRIB(2),,LAST,ALL(5);
      COLCT,INT(18),AVG GRP TM ESW;
      ACT,,,NS;
;
; ROAD MARCH BLOCK *****
; CANDIDATES ARRIVE AND CONDUCT THE RM. THEY ASSEMBLE INTO GROUPS
; BEFORE MOVING TO THE NEXT STATION.
;
;
RM   ASSIGN,ATRIB(13)=NUM_OF_GROUPS*GROUP_SIZE;
      BATCH,ATRIB(13),,LAST,ALL(5);

```

FRONT LINE AMBULANCE DURATION

LOAD & UNLOAD DEUCE DURATION

LOAD & UNLOAD 1 1/4 TON TRK DURATION

LOAD & UNLOAD HELICOPTER DURATION

```
UNBATCH,5;
ASSIGN,TOT_TM_RM=TNOW;
ACT,USERF(19);
BATCH,4/1,ATRIB(2),,LAST,ALL(5);
COLCT,INT(20),AVG GRP TM RM;
ACT,,,NS;
;
; DATA BLOCK *****
; THE TOTAL TIME IN SYSTEM FOR THE EFMB TEST IS COLLECTED.
;
;
DATA COLCT,INT(4),TOT TM IN SYS;
TERM;
;
END NETWORK;
;
FIN;
```

Appendix G

SIMULATION FORTRAN PROGRAM, SUBROUTINES, AND FUNCTIONS

```
*****
C
C THIS IS THE FORTRAN USER WRITTEN INSERT TO THE SLAM EFMB SIMULATION
C PROGRAM. THE INSERT CONTAINS FOUR PARTS: THE MAIN PROGRAM, AN
C INITIALIZATION SUBROUTINE (INTLC), A USER FUNCTION (USERF), AND AN
C OUTPUT ROUTINE.
C
C 1. THE MAIN PROGRAM REDIMENSIONS THE NSET/QSET STORAGE FOR THE SLAM
C NETWORK, ESTABLISHES THE SIZE OF THE CONTROLLING VARIABLES, AND SETS
C THE LOCATIONS OF THE INPUT/OUTPUT DEVICES.
C
C 2. THE INITIALIZATION SUBROUTINE INTERACTS WITH THE USER TO OBTAIN
C THE NUMBER OF CANDIDATES, THE NUMBER OF CANDIDATES PER GROUP, THE
C DAILY TRAINING DURATION, THE NUMBER OF LANES OR TASKS FOR SPECIFIC
C PORTIONS OF THE EFMB TEST, AND THE TEST SCHEDULE FOR EACH GROUP.
C IT ALSO PASSES INFORMATION TO THE OUTPUT DEVICE FOR INCLUSION IN
C THE SIMULATION OUTPUT REPORT.
C
C 3. THE USER FUNCTION ASSIGNS DURATION TIMES TO SPECIFIC EFMB
C ACTIVITIES, FACILITATES STATISTICS COLLECTION, AND SETS THE PARAMETER
C TO STOP AN INFEASIBLE EFMB STRATEGY. THIS FUNCTION IS CALLED AS
C NECESSARY BY THE SLAM SIMULATION PROGRAM.
C
C 4. THE OUTPUT SUBROUTINE COLLECTS STATISTICS OVER THE SIMULATION RUNS
C AND PRINTS THE RESULTS OF THE PARTICULAR SCENARIO. CPU TIME USED
C AND THE SUM OF THE THE TOTAL LATE AND SLACK TIMES ARE ALSO
C CALCULATED AND WRITTEN IN THE OUTPUT REPORT.
C
C ***** MAIN PROGRAM *****
C
C PROGRAM MAIN
C DIMENSION NSET(1100000)
C COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP
C NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,
C TNOW,XX(100)
C COMMON/UCOM1/ACCUM_A,IRCODE_A,NTERM
C COMMON QSET(1100000)
C EQUIVALENCE (NSET(1),QSET(1))
C NNSET=1100000
```

```

      CALL CPUTIME (ACCUM_A, IRCODE_A)
      NCRDR=5
      NPRNT=6
      NTAPE=7
      NTERM=10
      CALL SLAM
      STOP
      END

C
C ** INITIALIZATION SUBROUTINE *****
C   INTERACTS WITH THE USER TO OBTAIN THE PARAMETERS OF THE EFMB
C   STRATEGY TO BE ANALYZED. USING SUBROUTINE KODES, THE SCHEDULE
C   CODES ARE WRITTEN TO THE TERMINAL BEFORE THE SCHEDULE FOR EACH
C   GROUP IS ENTERED. USING SUBROUTINE CHECK, THE SCHEDULE CODES
C   ENTERED BY THE USER ARE CHECKED TO ENSURE THEY ARE VALID.
C   THESE TWO SUBROUTINES ARE LISTED FOLLOWING THIS INITIALIZATION
C   SUBROUTINE.
C
C   AS THE INPUT PROCESS IS BEING PERFORMED, THE INPUT PARAMETERS
C   ARE WRITTEN TO A DATA FILE FOR LATER USE IN THE INITIALIZATION
C   OF THE FOLLOWING SIMULATION RUNS.
C
C   THE PARAMETERS OF THE STRATEGY AND INFORMATION REPORT HEADINGS
C   ARE ALSO WRITTEN TO AN OUTPUT FILE AS PART OF THE FINAL RESULTS.
C   THESE PARAMETERS ARE THEN PASSED TO THE SLAM SIMULATION PROGRAM
C   AND THE SIMULATION IS CONDUCTED..
C
C   SUBROUTINE INTLC
C
C       COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,
C       NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,
C       TNOW,XX(100)
C       COMMON/UCOM1/ACCUM_A,IRCODE_A,NTERM
C       INTEGER ST1,ST2,REMT,DEUCE,QUARTER,HELI
C       DIMENSION X(4,13)
C       OPEN(UNIT=7,FILE='EXC',STATUS='UNKNOWN')
C
C   IF THE USER HAS ALREADY INPUT THE PARAMETERS FOR THE SIMULATION,
C   THE DATA SET HE HAS INPUT IS READ FROM THE DATA FILE FOR THE
C   ADDITIONAL SIMULATION RUNS.
C
C       IF (NNRUN.GT.1) THEN
C           READ(7,*) XX(1)
C           READ(7,*) XX(2)
C           READ(7,*) XX(4)
C           DO 5 I=1,XX(1)
C               DO 10 J=1,13

```

```

        READ(7,*) VALUE
        CALL PUTARY(I,J,VALUE)
        IF (X(I,J).EQ.9) THEN
            GOTO 5
        ENDIF
10      CONTINUE
5      CONTINUE
        READ(7,*) ST1
        CALL ALTER(3,ST1)
        READ(7,*) ST2
        CALL ALTER(4,ST2)
        READ(7,*) REMT
        CALL ALTER(5,REMT)
        READ(7,*) DEUCE
        CALL ALTER(15,DEUCE)
        READ(7,*) QUARTER
        CALL ALTER(16,QUARTER)
        READ(7,*) HELI
        CALL ALTER(17,HELI)
        IF (NNRUN.EQ.30) THEN
            GOTO 133
        ELSE
            GOTO 230
        ENDIF
    ENDIF
C
C      THE USER CREATES THE DATA FILE FOR THE SIMULATION BY INPUTTING THE
C      SIMULATION PARAMETERS.
C
        WRITE(10,*) NTERM
        WRITE(NTERM,*) NTERM

        WRITE(NTERM,15) 'INPUT THE PARAMETERS FOR THE PROJECTED EFMB
-SIMULATION RUN.'
15      FORMAT(A59)
        WRITE(NTERM,*)
        WRITE(NTERM,*) 'INPUT THE NUMBER OF GROUPS: =>'
        READ(NTERM,25) XX(1)
25      FORMAT(F1.0)
        WRITE(7,*) XX(1)
        WRITE(NTERM,*) 'INPUT THE NUMBER OF CANDIDATES PER GROUP: =>'
        READ(NTERM,30) XX(2)
30      FORMAT(F2.0)
        WRITE(7,*) XX(2)
        WRITE(NTERM,*) 'INPUT THE DAILY TRAINING DURATION IN HOURS: =>'
        READ(NTERM,35) XX(4)
35      FORMAT(F4.2)
        WRITE(7,*) XX(4)

```

```

C
C   INPUTS THE GROUP SCHEDULES
C
      DO 40 L = 1, XX(1)
        WRITE(NTERM,45) 'INPUT THE SCHEDULE FOR GROUP',L,'USING THE
        -CODES BELOW:'
45      FORMAT(A28,1X,I1,1X,A22)
        WRITE (NTERM,*)
        CALL CODES
        DO 50 I = 1,13
          55      WRITE(NTERM,60) 'INPUT CODE FOR SCHEDULE POSITION',I,' =>'
          60      FORMAT(A32,1X,I2,1X,A5)
            READ(NTERM,*) VALUE
            IF (VALUE.EQ.99) THEN
              GO TO 99
            ENDIF
            PAR=VALUE
            CALL CHECK(PAR,IFLAG)
            IF (IFLAG.EQ.1) THEN
              GO TO 55
            ENDIF
            WRITE(7,*) VALUE
            CALL PUTARY (L,I,VALUE)
            IF (VALUE.EQ.9) THEN
              GOTO 40
            ENDIF
            IF (VALUE .EQ.99) THEN      ! USER CAN EXIT SCHEDULE INPUT MODE
              GOTO 99
            ENDIF
50      CONTINUE
40    CONTINUE

C
C   PRINTS OUT SCHEDULE TO THE SCREEN FOR CHECK
C
      DO 70 N = 1, XX(1)
        WRITE (10,75) 'GROUP',N,'SCHEDULE IS:'
75      FORMAT(A5,1X,I1,1X,A12)
        WRITE (10,*)
        DO 80 I = 1, 13
          X(N,I) = GETARY(N,I)
          IF (X(N,I) .EQ. 9) THEN
            K=I
          ENDIF
          80      CONTINUE
          IF (K .LT. 13) THEN
            GOTO 85
          ELSE
            K=13
          
```



```

            ENDIF
85      WRITE(NTERM,90) (X(N,I), I=1,K)
90      FORMAT(13(F3.0,2X))
        WRITE(NTERM,*)
70  CONTINUE

C
C  INPUTS THE NUMBER OF STATION REPETITIONS OR RESOURCES
C
        WRITE(NTERM,*) 'INPUT THE NUMBER OF SURVIVAL TRAINING LANES: =>'
        READ(NTERM,95) ST1
95      FORMAT(I1)
        ST2=ST1*2
        CALL ALTER(3,ST1)
        WRITE(7,*) ST1
        CALL ALTER(4,ST2)
        WRITE(7,*) ST2
        WRITE(NTERM,*) 'INPUT THE NUMBER OF EMERGENCY MEDICAL TREATMENT
-STATIONS: =>'
        READ(NTERM,100) REMT
100     FORMAT(I1)
        CALL ALTER(5,REMT)
        WRITE(7,*) REMT
        WRITE(NTERM,*) 'INPUT THE NUMBER OF TWO AND ONE HALF TON TRUCK DUP
-LICATE TASKS: =>'
        READ(NTERM,105) DEUCE
105     FORMAT(I1)
        CALL ALTER(15,DEUCE)
        WRITE(7,*) DEUCE
        WRITE(NTERM,*) 'INPUT THE NUMBER OF QUARTER TON TRUCK DUPLICATE
-TASKS: =>'
        READ(NTERM,110) QUARTER
110     FORMAT(I1)
        CALL ALTER(16,QUARTER)
        WRITE(7,*) QUARTER
        WRITE(NTERM,*) 'INPUT THE NUMBER OF HELICOPTER DUPLICATE TASKS: =
->'
        READ(NTERM,115) HELI
115     FORMAT(I1)
        CALL ALTER(17,HELI)
        WRITE(7,*) HELI

C
C  PRINTS AN INFORMATION MESSAGE AND THE PARAMETERS OF THE SIMULATION.
C  INFORMATION ON INFEASIBLE SCENARIOS
C
        WRITE(NPRNT,*)
        WRITE(NPRNT,120) 'IF THE SCHEDULE IS NOT FEASIBLE AND CAUSES A GRO
-UP TO WORK THROUGHOUT THE '
120     FORMAT(A74)

```

```

WRITE(NPRNT,125) 'NIGHT AND INTO THE NEXT DAY, THE SIMULATION WILL
-TERMINATE AND THE RESULTS '
125  FORMAT(A74)
      WRITE(NPRNT,130) 'UP TO THE POINT OF INFEASIBILITY WILL BE PRINTED
      -'
130  FORMAT(A49)
      WRITE(NPRNT,*)
C
C  PRINTS PARAMETERS OF THE STRATEGY TO OUTPUT FILE
C
133  WRITE(NPRNT,*)
      WRITE(NPRNT,135) 'RESULTS OF THE SIMULATION FOR THE FOLLOWING EFMB
- TEST PARAMETERS:'
135  FORMAT(A65)
      WRITE(NPRNT,*)
      WRITE(NPRNT,140) 'NUMBER OF GROUPS',XX(1)
140  FORMAT(A16,2X,F3.0)
      WRITE(NPRNT,145) 'CANDIDATES PER GROUP',XX(2)
145  FORMAT(A20,2X,F3.0)
      WRITE(NPRNT,150) 'DAILY TRAINING DURATION',XX(4)
150  FORMAT(A23,2X,F3.1)
      WRITE(NPRNT,155) 'NUMBER OF SURVIVAL LANE REPETITIONS',NNRSC(3)
155  FORMAT(A35,2X,I1)
      WRITE(NPRNT,160) 'NUMBER OF EMERGENCY MEDICAL TREATMENT LANE
-REPETITIONS',NNRSC(5)
160  FORMAT(A54,2X,I1)
      WRITE(NPRNT,165) 'NUMBER OF TWO AND ONE HALF TON TRUCK
-TASKS',NNRSC(15)
165  FORMAT(A42,2X,I1)
      WRITE(NPRNT,170) 'NUMBER OF QUARTER TON TRUCK TASKS',NNRSC(16)
170  FORMAT(A33,2X,I1)
      WRITE(NPRNT,175) 'NUMBER OF HELICOPTER TASKS',NNRSC(17)
175  FORMAT(A26,2X,I1)
      WRITE(NPRNT,*)
      WRITE(NPRNT,*) 'SCHEDULE POSITIONS'
      WRITE(NPRNT,180)(A,A=1,13)
180  FORMAT(13(F3.0,2X))
      WRITE(NPRNT,*)
      DO 185 N = 1, XX(1)
          WRITE (NPRNT,190) 'GROUP',N,'SCHEDULE IS:'
190          FORMAT(A5,1X,I1,1X,1A12)
          WRITE (NPRNT,*)
          DO 195 I = 1, 13
              X(N,I) = GETARY(N,I)
              IF (X(N,I) .EQ. 9) THEN
                  K=I
              ENDIF
195          CONTINUE

```

```

        IF (K .LT. 13) THEN
            GOTO 200
        ELSE
            K=13
        ENDIF
200    WRITE(NPRNT,205)(X(N,i),i=1,K)
205    FORMAT(13(F3.0,2X))
        WRITE(NPRNT,*)
185    CONTINUE
        WRITE(NPRNT,*) 'SCHEDULE CODE ', 'EVENT'
        WRITE(NPRNT,*) '_____ ', '_____'
        WRITE(NPRNT,210) 1, 'DAY LAND NAVIGATION'
        WRITE(NPRNT,210) 2, 'NIGHT LAND NAVIGATION'
        WRITE(NPRNT,210) 3, 'SURVIVAL TRAINING'
        WRITE(NPRNT,210) 4, 'EMERGENCY MEDICAL TREATMENT AND CPR'
        WRITE(NPRNT,210) 5, 'LITTER OBSTACLE COURSE'
        WRITE(NPRNT,210) 6, 'COMMUNICATIONS'
        WRITE(NPRNT,210) 7, 'EVACUATION OF SICK AND WOUNDED'
        WRITE(NPRNT,210) 8, 'ROAD MARCH'
        WRITE(NPRNT,210) 9, 'ALL STATIONS COMPLETE'
        WRITE(NPRNT,210) 10, 'END OF DAY ONE TRAINING'
        WRITE(NPRNT,210) 20, 'END OF DAY TWO TRAINING'
        WRITE(NPRNT,210) 30, 'END OF DAY THREE TRAINING'
        WRITE(NPRNT,210) 40, 'END OF DAY FOUR TRAINING'
210    FORMAT(6X,I2,9X,1A)
        WRITE(NPRNT,*)
        IF (NNRUN.EQ.1) THEN
            WRITE(NPRNT,215) 'SUMMARY REPORT FOR THE FIRST SIMULATION
-RUN'
215    FORMAT(44X,1A)
            GOTO 230
        ELSE
            GOTO 220
        ENDIF
C
220    WRITE(NPRNT,*)
        WRITE(NPRNT,225) 'SPECIFIC LATE AND SLACK TIME INFORMATION FOR SIMU
-LATION RUN',NNRUN
225    FORMAT(A59,1X,I2)
        WRITE(NPRNT,*)
C
C    CANDIDATES ARE PLACED AT ENTER NODE #1 OF THE SLAM NETWORK
C    WITH ATTRIBUTES INITIALIZED.
C
230    DO 235 I= 1,XX(1)
        DO 240 J= 1,XX(2)
            ATRIB(1)=I
            ATRIB(2)=XX(2)

```

```

240      CALL ENTER (1,ATRI)
235      CONTINUE
C
      REWIND(UNIT=7)
99      RETURN
      END
C
C
C ** SCHEDULE CODES SUBROUTINE *****
C   SETS PARAMETERS FOR THE INPUT CHECKING SUBROUTINE AND WRITES
C   THE SCHEDULE CODES TO THE TERMINAL FOR USE IN INPUTING GROUP
C   SCHEDULES.
C
C   SUBROUTINE CODES
C
      COMMON/SCOM1/ATRI(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP
      NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,
      NOW,XX(100)
      COMMON/UCOM1/ACCUM_A,IRCODE_A,NTERM
      COMMON/UCOM2/KODES(15)
C
      KODES(1)=0.
      DO 5 I = 2,10
          KODES(I)=KODES(I-1) + 1.
5      CONTINUE
      KODES(11)=10.
      KODES(12)=20.
      KODES(13)=30.
      KODES(14)=40.
      KODES(15)=99.
C
      WRITE(NTERM,*)
      WRITE(NTERM,*) 'SCHEDULE CODE ', 'EVENT'
      WRITE(NTERM,*) '_____', '_____'
      WRITE(NTERM,10) 1, 'DAY LAND NAVIGATION'
      WRITE(NTERM,10) 2, 'NIGHT LAND NAVIGATION'
      WRITE(NTERM,10) 3, 'SURVIVAL TRAINING'
      WRITE(NTERM,10) 4, 'EMERGENCY MEDICAL TREATMENT AND CPR'
      WRITE(NTERM,10) 5, 'LITTER OBSTACLE COURSE'
      WRITE(NTERM,10) 6, 'COMMUNICATIONS'
      WRITE(NTERM,10) 7, 'EVACUATION OF SICK AND WOUNDED'
      WRITE(NTERM,10) 8, 'ROAD MARCH'
      WRITE(NTERM,10) 9, 'ALL STATIONS COMPLETE'
      WRITE(NTERM,10) 10, 'END OF DAY ONE TRAINING'
      WRITE(NTERM,10) 20, 'END OF DAY TWO TRAINING'
      WRITE(NTERM,10) 30, 'END OF DAY THREE TRAINING'
      WRITE(NTERM,10) 40, 'END OF DAY FOUR TRAINING'

```

```

      WRITE(NTERM,10) 99,'TERMINATE SCHEDULE INPUT; RETURN TO SYSTEM'
10    FORMAT (6X,I2,9X,1A)
      WRITE(NTERM,*)
      RETURN
      END

```

C

C ** SUBROUTINE CHECK *****

```

C    CHECKS THE USER INPUTS FOR PROPER SCHEDULE CODES AND PROMPTS
C    THE USER TO REENTER IF THERE IS AN ERROR.
C
C

```

C

C

C SUBROUTINE CHECK(PAR,IFLAG)

C

```

      COMMON/SCOM1/ATTRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,
      NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,
      TNOW,XX(100)

```

```

      COMMON/UCOM1/ACCUM_A,IRCODE_A,NTERM

```

```

      COMMON/UCOM2/KODES(15)

```

```

      IFLAG=0

```

```

      DO 5 K=2,15

```

```

          IF (PAR.EQ.KODES(K)) THEN

```

```

              GO TO 10

```

```

          ENDIF

```

```

5      CONTINUE

```

```

      WRITE(NTERM,*) 'LAST PARAMETER INPUT IS NOT A VALID CODE. PLEASE
      -REENTER.'

```

```

      IFLAG=1

```

```

10     RETURN

```

```

      END

```

C

C

C ** ACTIVITY DURATION FUNCTION *****

```

C    THIS FUNCTION INTERACTS WITH THE SLAM SIMULATION PROGRAM TO
C    ASSIGN TIME DURATIONS TO ACTIVITIES, TO FACILITATE STATISTICS
C    COLLECTION, AND TO SET THE INITIAL PARAMETER TO STOP THE
C    SIMULATION PROGRAM IF THE EFMB STRATEGY IS INFEASIBLE.
C

```

C

```

C    IN ORDER TO FACILITATE ANY FUTURE MODIFICATION TO THE ACTIVITY
C    DURATIONS USED IN THE SIMULATION PROGRAM, ALL ACTIVITY DURATIONS
C    ARE LISTED IN THIS SUBROUTINE. THE PARAMETERS OF THE TIME
C    DURATIONS FOR THE SENSITIVITY ANALYSIS ARE LISTED ABOVE
C    THE EXPECTED VALUES THAT WERE USED THROUGHOUT THE SIMULATION
C    STUDY. STATISTICS ON LATE AND SLACK TIME ARE COLLECTED FOR
C    EACH SIMULATION RUN, AND, FOR THE LAST SIMULATION RUN, A DETAILED
C    REPORT ON THE LATE AND SLACK TIME FOR THE STRATEGY IS WRITTEN
C    TO THE OUTPUT FILE.
C
C
C

```

C

C

```

      FUNCTION USERF(IFN)
C
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,MSTOP,
      NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,
      TNOW,XX(100)
C
      GO TO (1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23
      -24,25,26,27,28), IFN
C
C      DAY LAND NAVIGATION
C      1  USERF = RNORM(2.11,.41,1)
      RETURN
C
C      NIGHT LAND NAVIGATION
C      2  USERF = RNORM(2.15,.6,1)
      RETURN
C
C      SURVIVAL TRAINING—FIRST THREE TASKS
C      3  USERF = RNORM(.15,.03,1)      ! USED FOR SENSITIVITY ANALYSIS
C      3  USERF = .15
      RETURN
C
C      SURVIVAL TRAINING—REMAINING TASKS
C      4  USERF = RNORM(1.18,.13,1)      ! USED FOR SENSITIVITY ANALYSIS
C      4  USERF = 1.18
      RETURN
C
C      CARDIOPULMONARY RESUSCITATION
C      5  USERF = RNORM(.04,.01,1)      ! USED FOR SENSITIVITY ANALYSIS
C      5  USERF = .04
      RETURN
C
C      EMERGENCY MEDICAL TREATMENT
C      6  USERF = RNORM(.76,.1,1)      ! USED FOR SENSITIVITY ANALYSIS
C      6  USERF = .76
      RETURN
C
C      LITTER OBSTACLE COURSE
C      7  USERF = RNORM(.53,.07,1)      ! USED FOR SENSITIVITY ANALYSIS
C      7  USERF = .53
      RETURN
C
C      COMMUNICATIONS—MEDIVAC
C      8  USERF = RNORM(.12,.07,1)      ! USED FOR SENSITIVITY ANALYSIS
C      8  USERF = .12
      RETURN
C

```

```

C   COMMUNICATIONS--RADIO NET
9   USERF = RNORM(.11,.01,1)           ! USED FOR SENSITIVITY ANALYSIS
9   USERF = .11
    RETURN

C
C   COMMUNICATIONS--OPERATE RADIO & TELEPHONES
10  USERF = .1
    RETURN

C
C   EVACUATION OF SICK AND WOUNDED(ESW)--IMPROLIT
11  USERF = .09
    RETURN

C
C   ESW--FOUR_H
12  USERF = .02
    RETURN

C
C   ESW--FIRMAN
13  USERF = .03
    RETURN

C
C   ESW--PISTOL
14  USERF = RNORM(.1,.01,1)           ! USED FOR SENSITIVITY ANALYSIS
14  USERF = .1
    RETURN

C
C   ESW--FLA
15  USERF = RNORM(.12,.02,1)           ! USED FOR SENSITIVITY ANALYSIS
15  USERF = .12
    RETURN

C
C   ESW--DEUCE
16  USERF = RNORM(.19,.01,1)           ! USED FOR SENSITIVITY ANALYSIS
16  USERF = .19
    RETURN

C
C   ESW--QUARTER
17  USERF = RNORM(.15,.03,1)           ! USED FOR SENSITIVITY ANALYSIS
17  USERF = .15
    RETURN

C
C   ESW--HELI
18  USERF = RNORM(.15,.02,1)           ! USED FOR SENSITIVITY ANALYSIS
18  USERF = .15
    RETURN

C

```

```

C   ROAD MARCH
19  USERF = RNORM(2.74,.16,1)
    RETURN

C
C   STATISTICS COLLECTION CODE FOR LATENESS
C
20  CLATE = ATRIB(13)
    CALL COLCT (CLATE,32)
    IF (NNRUN.EQ.30) THEN
        GOTO 30
    ELSE
        GOTO 31
    ENDIF
30  WRITE(NPRNT,32) 'GROUP:',ATRIB(1),'SCHEDULE POSITION:',ATRIB(3),'L
    -ATE TIME:',ATRIB(13)
32  FORMAT(A6,2X,F2.0,2X,A18,2X,F3.0,2X,A11,2X,F13.9)
31  USERF = 0
    RETURN

C
C   STATISTICS COLLECTION CODE FOR SLACK TIME
C
21  SLACK = ATRIB(13)
    CALL COLCT (SLACK,31)
    IF (NNRUN.EQ.30) THEN
        GOTO 40
    ELSE
        GOTO 41
    ENDIF
40  S4=ATRIB(3)-1
    WRITE(NPRNT,42) 'GROUP:',ATRIB(1),'SCHEDULE POSITION:',S4,'SLACK T
    -IME:',ATRIB(13)
42  FORMAT(A6,2X,F2.0,2X,A18,2X,F3.0,2X,A11,2X,F13.9)
41  USERF = 0
    RETURN

C
C   CODE TO STOP THE SIMULATION FOR AN UNFEASIBLE SCHEDULE
22  MSTOP = -1
    USERF = 0
    RETURN

C
C   MOVEMENT TIME TO DLN COURSE
23  USERF = .5
    RETURN

C
C   TIME FOR MAP ISSUE, 100 METER PACE COURSE PRACTICE, ETC.
24  USERF = .5
    RETURN

```



```

C
C  TIME TO MOVE TO NLN COURSE
25  USERF = .5
    RETURN

C
C  INSTRUCTIONS AND COMPASS CHECK FOR THE NLN COURSE
26  USERF = .5
    RETURN

C
C  MOVEMENT TO THE LITTER OBSTACLE COURSE
27  USERF = .33
    RETURN

C
C  INSTRUCTIONS AND TEAM FORMING AT LOC
28  USERF = .33
    RETURN
    END

C
C ** FINAL STATISTICS SUBROUTINE *****
C
C
C  COLLECTS STATISTICS AFTER COMPLETION OF EACH RUN. THESE
C  STATISTICS ARE FOR THE AVERAGE TIME TO COMPLETE THE EFMB
C  STRATEGY, THE AVERAGE NUMBER OF GROUPS WORKING LATE AND
C  FINISHING EARLY FOR THE STRATEGY, THE AVERAGE GROUP TIME
C  WORKING LATE AND FINISHING EARLY FOR THE STRATEGY, THE
C  AVERAGE GROUP TIME TO COMPLETE EACH STATION, AND THE AVERAGE
C  WAITING TIME FOR EACH STATION OR TASK MODELLED AS A RESOURCE.
C
C  THESE STATISTICS ARE AVERAGED IN THE FINAL SUMMARY REPORT
C  TO OBTAIN INFORMATION OVER THE 30 EFMB SIMULATED TESTS.
C
C  ADDITIONAL INFORMATION AVAILABLE IN THE OUTPUT REPORT:
C  - A WARNING IS WRITTEN TO THE OUTPUT FILE IF THE MAXIMUM TIME
C  TO COMPLETE THE NIGHT LAND NAVIGATION COURSE EXCEEDS SIX HOURS.
C  - THE CPU TIME USED FOR THE 30 SIMULATED EFMB TESTS IS
C  CALCULATED AND INCLUDED IN THE OUTPUT REPORT.
C  - THE AVERAGE TOTAL LATE TIME, AVERAGE TOTAL SLACK TIME, AND
C  THE SUM OF THE TWO ARE CALCULATED.
C
C
C  SUBROUTINE OPUT

C
C  COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,IL,MFA,MSTOP,
C  NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),SSL(100),TNEXT,
C  TNOW,XX(100)
C  COMMON/UCOM1/ACCUM_A, IRCODE_A
C

```

C STATISTICS OVER SIMULATION RUNS FOR AVERAGE TOTAL EFMB TEST TIME,
 C AVERAGE GROUP COMPLETION TIME, AVERAGE LATE TIME, AND AVERAGE SLACK
 C TIME

C TSYS = CCAVG(74)
 CALL COLCT(TSYS,1)

C TLATE = CCAVG(32)
 CALL COLCT(TLATE,2)

C ANUM = CCNUM(32)
 CALL COLCT(ANUM,3)

C ASLACK = CCAVG(31)
 CALL COLCT(ASLACK,4)

C BSLACK = CCNUM(31)
 CALL COLCT(BSLACK,5)

C ADLN = CCAVG(42)
 CALL COLCT(ADLN,6)

C ANLN = CCAVG(47)
 CALL COLCT(ANLN,7)

C AST = CCAVG(52)
 CALL COLCT(AST,8)

C AEMT = CCAVG(57)
 CALL COLCT(AEMT,9)

C ALOC = CCAVG(62)
 CALL COLCT(ALOC,10)

C ACOM = CCAVG(67)
 CALL COLCT(ACOM,11)

C AESW = CCAVG(72)
 CALL COLCT(AESW,12)

C ARM = CCAVG(73)
 CALL COLCT(ARM,13)

C AVERAGE TASK/STATION WAITING TIMES

C ARDLN = FFAWT(1)
 CALL COLCT(ARDLN,14)

C ARNLN = FFAWT(2)
 CALL COLCT(ARNLN,15)

C ARST1 = FFAWT(3)
 CALL COLCT(ARST1,16)

C ARST2 = FFAWT(4)
 CALL COLCT(ARST2,17)

C AREMR = FFAWT(5)
 CALL COLCT(AREMR,18)

C ARLOC = FFAWT(6)
 CALL COLCT(ARLOC,19)

C ACM = FFAWT(7)
 CALL COLCT(ACM,20)

C ACR = FFAWT(8)
 CALL COLCT(ACR,21)

C ACO = FFAWT(9)
 CALL COLCT(ACO,22)

C AIMPR = FFAWT(10)
 CALL COLCT(AIMPR,23)

C AFOUR = FFAWT(11)
 CALL COLCT(AFOUR,24)

C AFIRM = FFAWT(12)
 CALL COLCT(AFIRM,25)

C APIST = FFAWT(13)
 CALL COLCT(APIST,26)

C AFLA = FFAWT(14)
 CALL COLCT(AFLA,27)

C ADEUC = FFAWT(15)
 CALL COLCT(ADEUC,28)

C AQUAR = FFAWT(16)
 CALL COLCT(AQUAR,29)

C AHELI = FFAWT(17)
 CALL COLCT(AHELI,30)

```

C      WRITE(NTERM,10) 'COMPLETED SIMULATION RUN NUMBER',NNRUN
10     FORMAT(A31,1X,I2)
C
      IF (NNRUN.EQ.30) THEN
          GOTO 80
      ELSE
          GOTO 81
      ENDIF

C
C      PRINTS WARNING IF THE NIGHT LAND NAVIGATION LANE EXCEEDS SIX HOURS
C
80     WRITE(NPRNT,*)
        ANLNX = CCMAX(7)
        IF (ANLNX.GT.6) THEN
            WRITE(NPRNT,20) 'NIGHT LAND NAVIGATION STATION APPEARS TO
- TAKE TOO LONG'
20         FORMAT(A54)
            WRITE(NPRNT,30) 'CONSIDER SCHEDULING GROUPS ON DIFFERENT
- NIGHTS.'
30         FORMAT(A47)
            ENDIF
            WRITE(NPRNT,*)
            CALL CPUTIME (ACCUM_B, IRCODE_B)
            IF (IRCODE_A .NE. 8 .AND. IRCODE_B .EQ. 0) THEN
                USED_TIME = ACCUM_B - ACCUM_A
                WRITE(NPRNT,*) USED_TIME, 'MICROSECONDS OF CPU TIME WERE
- USED'
            END IF

C
C      CALCULATION OF TOTAL AVERAGE LATE AND TOTAL AVERAGE SLACK TIMES
C      AND SENDS THESE TO THE OUTPUT FILE. ALSO CALCULATES THE CPU TIME
C      USED.
C
        FLATETM=CCAVG(2)
        FSLACKTM=CCAVG(4)
        FLATENUM=CCAVG(3)
        FSLACKNUM=CCAVG(5)
        P1=FLATETM*FLATENUM
        P2=FSLACKTM*FSLACKNUM
        WRITE(NPRNT,*)
        WRITE(NPRNT,40) 'AVERAGE TOTAL LATE TIME IS:',P1
40     FORMAT(A27,2X,F13.9)
        WRITE(NPRNT,50) 'AVERAGE TOTAL SLACK TIME IS:',P2
50     FORMAT(A28,2X,F13.9)
        WRITE(NPRNT,60) 'AVERAGE TOTAL TIME LATE PLUS AVERAGE TOTAL SLACK
- TIME:',P1+P2
60     FORMAT(A54,2X,F13.9)

```

```
WRITE(NPRNT,*)  
WRITE(NPRNT,70)'SUMMARY REPORT FOR THE LAST SIMULATION RUN'  
70  FORMAT(44X,1A)  
81  RETURN  
END
```

BIBLIOGRAPHY

- [1] Expert Field Medical Badge Test TC 8-100, Washington D.C., U.S. Army, 1988.

- [2] Park, Yang Byung, "Evaluation of Static Flowshop Scheduling Heuristics in Dynamic Flowshop Models via a Computer Simulation", Computers & Industrial Engineering, v. 14 n 2 pp 103-112, 1988.

- [3] Law, Averill M. and W. David Kelton, Simulation Modelling and Analysis, McGraw-Hill Inc., New York, 1991.

- [4] Pultar, Mustafa, "Progress-Based Construction Scheduling", Journal of Construction Engineering and Management, v. 116 n 4, pp 670-688, December 1990.

- [5] Drewin, F. J., Construction Productivity Measure and Improvement through Workstudy, Second Edition, Elsevier Science Publishing Co., Inc., 1982.

- [6] Niebel, Benjamin W., Motion and Time Study, Eighth Edition, Irwin Inc., Illinois, 1988.

- [7] Truscott, William G. and Duk I. Cho, "Scheduling Batch Production with Character Graphics", Industrial Engineering, v 19, pp 17-22, February 1987.

- [8] Weeks, J. K., "A simulation Study of Predictable Due Dates", Management Science, v 25, pp 363-373, 1979.

- [9] Gonzalez, T. and Sahni, S., "Open Shop Scheduling to Minimize Finish Time", Journal of the Association for Computing Machinery, v 23, pp 665-679, October 1976.

- [10] Jacobs, R. F., and Bragg, D. J., "Repetitive Lots: Flow-Time Reductions Through Sequencing and Dynamic Batch Sizing", Decision Sciences, v 19(2) pp 281-294, 1988.
- [11] Pinedo, M., "On the Optimal Order of Stations in Tandem Queues", Applied Probability-Computer Science: The Interface, Birkhaeuser, Boston v II pp 307-325, 1982.
- [12] El-Rayah J., "The Efficiency of Balanced and Unbalanced Production Lines", International Journal of Production Research, v 17 no 1 pp 61-75, 1979.
- [13] Pritsker, A. Alan B. and Claude Dennis Pegden, Introduction to Simulation and SLAM, Halsted Press, New York, 1979.
- [14] Michael Pinedo, and Linus Schrage, "Stochastic Shop Scheduling: A survey," Deterministic and Stochastic Scheduling, pp. 181-196, Boston: D. Reidel Publishing Company, 1982.
- [15] Montgomery, Douglas C., Design and Analysis of Experiments, John Wiley & Sons, Inc., New York, 1991.

VITA

John Charles Sees Jr. was born in Fort Eustis, Virginia, on January 6, 1960, the son of Eva Maria Sees and John Charles Sees Sr. After completing his work at Widefield High School, Security, Colorado, in 1978, he entered the University of Notre Dame. He received the degree of Bachelor of Business Administration from Notre Dame and received his commission in the United States Army as a Second Lieutenant in May, 1982. During the following years he served as a platoon leader, company executive officer, and company commander in former West Germany. In August, 1990, he entered The Graduate School of The University of Texas.

Permanent address: 510 Leta Drive
Security, Colorado 80911

This report was typed by the author